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ONE-HUNDRED-AND-THIRTY-FIFTH SESSION, 1888-89.

SESSIONAL ARRANGEMENTS.

The First Meeting of the One Hundred and Thirty-fifth Session of the Society was held on Wednesday, the 21st November, when the Opening Address was delivered by The Duke of Abercorn, C.B., Chairman of the Council. Previous to Christmas there will be four Ordinary Meetings, when papers will be read by Colonel Gouraud, Mr. Edmunds, Mr. Deering, and Mr. Dibdin.

ORDINARY MEETINGS.

Wednesday evening, at Eight o'clock. The following dates have been fixed :—

November 28.—"The Phonograph." By Colonel Gouraud. Sir Frederick Bramwell, D.C.L., F.R.S., Deputy-Chairman of the Council, will preside.

December 5.—"The Graphophone." By Henry Edmunds. W. H. Preece, F.R.S., will preside.

" 19.—"Standards of Light." By W. J. Dibdin, F.I.C., F.C.S.

" 12.—"Explosives." W. H. Deering, F.C.S. Sir Frederick Abel, C.B., D.C.L., F.R.S., President of the Government Commission on Explosives, will preside.

For meetings after Christmas—

Edouard Garnier (late Director of the Sèvres Manufactory), "Manufacture of Sèvres Porcelain."

Benjamin Baker, M.Inst.C.E., "The Forth Bridge."

Colonel Hozier, "The Channel Tunnel."

Peter Lund Simmonds, "Salt."

Conrad Beck, "The Construction of Photographic Lenses."

William Anderson, M.Inst.C.E., "The Manufacture of Aluminium."
J. G. Lorrain, "Automatic Selling Machines."
W. H. Preece, F.R.S., "Secondary Batteries."
Prof. Silvanus P. Thompson, "Arc Lamps and their Mechanism."

FOREIGN AND COLONIAL SECTION.

The meetings of this Section will take place on the following Tuesday evenings, at Eight o'clock:—
January 29; February 19; March 12; April 2, 30; May 21.

INDIAN SECTION.

The meetings of this Section will take place on the following Friday evenings, at Eight o'clock:—
January 25; February 15; March 8, 29; May 3, 24.

APPLIED ART SECTION.

The meetings of this Section will take place on the following Tuesday evenings, at Eight o'clock:—
January 22; February 5, 26; March 19; April 9; May 14.

CANTOR LECTURES.

The following courses of Cantor Lectures will be delivered on Monday evenings at Eight o'clock:—

Captain W. de W. Abney, C.B., F.R.S., "Light and Colour." Four Lectures,

Lecture I.—November 26.—The production of colour and its dependence on the kind of illuminant.—Simple colours.—The characteristics of colour.—Interference colours.

Lecture II.—December 3.—Production of colour by absorption; by fluorescence.—The measurement of the luminosity of colours.—The effect of the dilution of colours.—Colour contrast.—Colour-blindness.

Lecture III.—December 10.—Mixtures of colours.—Impure colours.—Effect of ground in water colours.—The measurement of colour in terms of a standard.—The reproduction of the colours of a pigment.

Lecture IV.—December 17.—The action of light on pigments.—The cause of change.—The effect of sunlight, sky-light and artificial light.—Rays effective in causing change.—Moisture and oxygen necessary to cause change.

Alan S. Cole, "Egyptian Tapestry." Two Lectures.
Jan. 21, 28.

W. J. Linton, "Wood Engraving." Two Lectures.
Feb. 11, 18.

Walter Crane, "The Decoration and Illustration of Books." Three Lectures.
March 4, 11, 18.

C. V. Boys, F.R.S., "Instruments for the Measurement of Heat." Four Lectures.
March 25; April 1, 8, 15.

H. Graham Harris, M.Inst.C.E., "Heat Engines other than Steam." Four Lectures.
May 6, 13, 20, 27.

JUVENILE LECTURES.

Two Juvenile Lectures, entitled "How Chemists Work—an example to Boys and Girls," by Henry E. Armstrong, Ph.D., F.R.S., will be given on Wednesday evenings, January 2 and 9, 1889, at Seven o'clock.

PROCEEDINGS OF THE SOCIETY.

Charter.—The Society of Arts was founded in 1754, and incorporated by Royal Charter in 1847, for "The Encouragement of the Arts, Manufactures, and Commerce of the Country, by bestowing rewards for such productions, inventions, or improvements as tend to the employment of the poor, to the increase of trade, and to the riches and honour of the kingdom; and for meritorious works in the various departments of the Fine Arts; for Discoveries, Inventions, and Improvements in Agriculture, Chemistry, Mechanics, Manufactures, and other useful Arts; for the application of such natural and artificial products, whether of Home, Colonial, or Foreign growth and manufacture, as may appear likely to afford fresh objects of industry, and to increase the trade of the realm by extending the sphere of British commerce; and generally to assist in the advancement, development, and practical application of every department of science in connection with the Arts, Manufactures, and Commerce of this country."

The Session.—The Session commences in November, and ends in June. The number of Meetings held during the Session amounts to between 70 and 80.

ORDINARY MEETINGS.—At the Wednesday Evening Meetings during the Session papers on subjects relating to inventions, improvements, discoveries, and other matters connected with the Arts, Manufactures, and Commerce of the country are read and discussed.

INDIAN SECTION.—This Section was established in 1869, for the discussion of subjects connected with our Indian Empire. Six or more Meetings are held during the Session.

FOREIGN AND COLONIAL SECTION.—This Section was formed in 1874, under the title of the African Section, for the discussion of subjects connected with the Continent of Africa. It was enlarged in 1879, so as to include the consideration of subjects connected with our Colonies and Dependencies, and with Foreign Countries. Six or more Meetings are held during the Session.

APPLIED ART SECTION.—This Section was formed in 1886 for the discussion of subjects connected with the industrial applications of the Fine Arts. Six or more meetings are held during the Session.

CANTOR LECTURES.—These Lectures originated in 1863, with a bequest by the late Dr. Cantor. There are several Courses every Session, and each course consists generally of two or more Lectures.

ADDITIONAL LECTURES.—Special Courses of Lectures are occasionally given.

JUVENILE LECTURES.—A short Course of Lectures, suited for a Juvenile audience, is delivered to the Children of Members during the Christmas Holidays.

ADMISSION TO MEETINGS.—Members have the right of attending the above Meetings and Lectures. They require no tickets, but are admitted on signing their names. Every Member can admit *two* friends to the Ordinary and Sectional Meetings, and *one* friend to the Cantor and other Lectures. Books of tickets for the purpose are supplied to the Members, but admission can be obtained on the personal introduction of a Member. For the Juvenile Lectures special tickets are issued.

JOURNAL OF THE SOCIETY OF ARTS.—The *Journal*, which is sent free to Members, is published weekly, and contains full Reports of all the Society's Proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce.

EXAMINATIONS.—Examinations are held annually by the Society, through the agency of Local Committees, at various centres in the country. They are open to any person. The subjects include the principal divisions of a Commercial Education, Political and Domestic Economy, and Music. A Programme, containing detailed information about the Examinations, can be had on application to the Secretary.

LIBRARY AND READING-ROOM.—The Library and Reading-room are open to Members, who are also entitled to borrow books.

CONVERSAZIONI are held, to which the Members are invited, each Member receiving a card for himself and a Lady.

MEMBERSHIP.

The Society numbers at present between three and four thousand Members. The Annual Subscription is Two Guineas, payable in advance, and dates from the quarter-day preceding election; or a Life Subscription of Twenty Guineas may be paid.

Every Member whose subscription is not in arrear is entitled:—

To be present at the Evening Meetings of the Society, and to introduce two visitors at such meetings, subject to such special arrangements as the Council may deem necessary to be made from time to time.

To be present and vote at all General Meetings of the Society.

To be present at the Cantor and other Lectures, and to introduce one visitor.

To have personal free admissions to all Exhibitions held by the Society at its house in the Adelphi.

To be present at all the Society's *Conversazioni*.

To receive a copy of the Weekly *Journal* published by the Society.

To the use of the Library and Reading-room.

Candidates for Membership are proposed by three Members, one of whom, at least, must sign on personal knowledge; or are nominated by the Council.

All subscriptions should be paid to the Secretary, H. T. Wood, and all Cheques or Post-office Orders should be crossed "Coutts and Company," and forwarded to him at the Society's House, John-street, Adelphi, London, W.C

H. TRUEMAN WOOD, *Secretary*.

CALENDAR FOR THE SESSION.

The following is the Calendar for the Session 1888-9. It is issued subject to any necessary alterations:—

NOVEMBER, 1888.

1	Th	
2	F	
3	S	
4	**S**	
5	M	
6	Tu	
7	W	
8	Th	
9	F	
10	S	
11	**S**	
12	M	
13	Tu	
14	W	
15	Th	
16	F	
17	S	
18	**S**	
19	M	
20	Tu	
21	W	Ordinary Meeting (Opening Meeting of the Session)
22	Th	
23	F	
24	S	
25	**S**	
26	M	Cantor Lecture I. 1
27	Tu	
28	W	Ordinary Meeting
29	Th	
30	F	

DECEMBER, 1888.

1	S	
2	**S**	
3	M	Cantor Lecture I. 2
4	Tu	
5	W	Ordinary Meeting
6	Th	
7	F	
8	S	
9	**S**	
10	M	Cantor Lecture I. 3
11	Tu	
12	W	Ordinary Meeting
13	Th	
14	F	
15	S	
16	**S**	
17	M	Cantor Lecture I. 4
18	Tu	
19	W	Ordinary Meeting
20	Th	
21	F	
22	S	
23	**S**	
24	M	
25	Tu	Christmas Day
26	W	*Bank Holiday*
27	Th	
28	F	
29	S	
30	**S**	
31	M	

JANUARY, 1889.

1	Tu	
2	W	Juvenile Lecture 1
3	Th	
4	F	
5	S	
6	**S**	
7	M	
8	Tu	
9	W	Juvenile Lecture 2
10	Th	
11	F	
12	S	
13	**S**	
14	M	
15	Tu	
16	W	Ordinary Meeting
17	Th	
18	F	
19	S	
20	**S**	
21	M	Cantor Lecture II. 1
22	Tu	Applied Art Section
23	W	Ordinary Meeting
24	Th	
25	F	Indian Section
26	S	
27	**S**	
28	M	Cantor Lecture II. 2
29	Tu	For. & Col. Section
30	W	Ordinary Meeting
31	Th	

FEBRUARY, 1889.

1	F	
2	S	
3	**S**	
4	M	
5	Tu	Applied Art Section
6	W	Ordinary Meeting
7	Th	
8	F	
9	S	
10	**S**	
11	M	Cantor Lecture III. 1
12	Tu	
13	W	Ordinary Meeting
14	Th	
15	F	Indian Section
16	S	
17	**S**	
18	M	Cantor Lecture III. 2
19	Tu	For. & Col. Section
20	W	Ordinary Meeting
21	Th	
22	F	
23	S	
24	**S**	
25	M	
26	Tu	Applied Art Section
27	W	Ordinary Meeting
28	Th	

MARCH, 1889.

1	F	
2	S	
3	**S**	
4	M	Cantor Lecture IV. 1
5	Tu	
6	W	Ordinary Meeting
7	Th	
8	F	Indian Section
9	S	
10	**S**	
11	M	Cantor Lecture IV. 2
12	Tu	For. & Col. Section
13	W	Ordinary Meeting
14	Th	
15	F	
16	S	
17	**S**	
18	M	Cantor Lecture IV. 3
19	Tu	Applied Art Section
20	W	Ordinary Meeting
21	Th	
22	F	
23	S	
24	**S**	
25	M	Cantor Lecture V. 1
26	Tu	
27	W	Ordinary Meeting
28	Th	
29	F	Indian Section
30	S	
31	**S**	

APRIL, 1889.

1	M	Cantor Lecture V. 2
2	Tu	For. & Col. Section
3	W	Ordinary Meeting
4	Th	
5	F	
6	S	
7	**S**	
8	M	Cantor Lecture V. 3
9	Tu	Applied Art Section
10	W	Ordinary Meeting.
11	Th	
12	F	
13	S	
14	**S**	
15	M	Cantor Lecture V. 4
16	Tu	
17	W	
18	Th	
19	F	Good Friday
20	S	
21	**S**	Easter Sunday
22	M	*Bank Holiday*
23	Tu	
24	W	
25	Th	
26	F	
27	S	
28	**S**	
29	M	
30	Tu	For. & Col. Section

MAY, 1889.

1	W	Ordinary Meeting
2	Th	
3	F	Indian Section
4	S	
5	**S**	
6	M	Cantor Lecture VI. 1
7	Tu	
8	W	Ordinary Meeting
9	Th	
10	F	
11	S	
12	**S**	
13	M	Cantor Lecture VI. 2
14	Tu	Applied Art Section
15	W	Ordinary Meeting
16	Th	
17	F	
18	S	
19	**S**	
20	M	Cantor Lecture VI. 3
21	Tu	For. & Col. Section
22	W	Ordinary Meeting
23	Th	
24	F	Indian Section
25	S	
26	**S**	
27	M	Cantor Lecture VI. 4
28	Tu	
29	W	Ordinary Meeting
30	Th	
31	F	

JUNE, 1889.

1	S	
2	**S**	
3	M	
4	Tu	
5	W	
6	Th	
7	F	
8	S	
9	**S**	Whit Sunday
10	M	*Bank Holiday*
11	Tu	
12	W	
13	Th	
14	F	
15	S	
16	**S**	
17	M	
18	Tu	
19	W	Annual Conversazione (probable date)
20	Th	
21	F	
22	S	
23	**S**	
24	M	
25	Tu	
26	W	Annual General Meeting
27	Th	
28	F	
29	S	
30	**S**	

The chair will be taken at eight o'clock at each of the above meetings, except the Annual General Meeting and the Juvenile Lectures.

The Annual General Meeting will be held at four o'clock.

The Juvenile Lectures will be given at seven o'clock.

NOTICES.

PHONOGRAPH AND GRAPHOPHONE.

All the tickets for the meetings of the Society on November 28th and December 5th having now been disposed of, the issue is stopped.

As all the available accommodation will be required for those members who have applied for tickets, it will be understood that no member can be admitted without a ticket.

Proceedings of the Society.

FIRST ORDINARY MEETING.

Wednesday evening, November 21st, 1888, the DUKE of ABERCORN, C.B., Chairman of the Council, in the chair.

The following candidates were proposed for election as members of the Society:—

Agnew, Charles Morland, M.A., 39B, Old Bond-street, W.
Bailey, Richard, 12, Leazes-place, Durham.
Bartholomew, Charles William, Blakesley-hall, near Towcester, Northamptonshire.
Bonus, Major-General Joseph, The Cedars, Strawberry-hill, Twickenham.
Brown, Thomas, King's Lynn, Norfolk.
Brown, William, 67, Renfield-street, Glasgow.
Buckeridge, Herbert Leighton, Leighton-villa, Cheverton-road, Hornsey-lane, N.
Bush, William Ernest, 21, Artillery-lane, E.
Butler, William Waters, Crown Brewery, Birmingham.
Cart, Rev. Henry Thomas, Oakhurst, Upper Norwood, S.E.
Cecil-Johnson, Colonel Edmund, United Service Club, Pall Mall, S.W.
Chalmers, Alexander B., Scottish Club, 39, Dover-street, Piccadilly, W.
Clapham, W. W., 35, Church-street, Manchester.
Cochran, Alexander, 22, Blythswood-square, Glasgow.
Cook, Henry John, The Firs, Woodford, Essex.
Corbett, James Andrew, Castle-street, Cardiff.
Cotterill, William, Tongswood, Hawkhurst.
Craig, James, Llyndally, Palace-road, Tulse-hill, S.W.
Cunningham, Hon. Justice, 6, Onslow-gardens, S.W.
Daniell, John Henry, 4, Lombard-street, E.C.
De Negri, C., 68, Stamford-street, S.E.
Derham, Benjamin, M.D., 110, St. George's-road, Bolton-le-Moors.
Edmunds, Henry, 10, Hatton-garden, E.C.
Filliter, Edward, 3, Rosslyn-hill, Hampstead, N.W.
Freeman, Francis, 63, Pall Mall, S.W.
Gedge, Alfred Sydney, 3, Great James-street, Bedford-row, W.C.
Gilbert, Josiah, Marden Ash, Ongar, Essex.
Gow, Alfred, St. Julian's-road, Streatham, S.W.
Haas, Hendrick C. 32, Fenchurch-street, E.C.
Hall, Samuel, 19, Aberdeen-park, Highbury, N.
Haller, George, 86, Leadenhall-street, E.C.
Hammersley, Hugh Greenwood, 6, Chelsea-embankment, S.W.
Hardy, George Francis, 5, Whitehall, S.W.
Harris, William A., Phœnix-chambers, Exchange, Liverpool.
Hartland, W. H. Hill, 114, Hyde-park-street, Glasgow.
Harvey, Thomas Morgan, 1, Gresham-buildings, Basinghall-street, E.C.
Heap, Ralph, jun., 1, Brick-court, Temple, E.C.
Heighway, Thomas, 19, John Dalton-street, Manchester.
Herbert, Wilfrid V., 40, Scarsdale-villas, Kensington, W.
Hewetson, Frank, Grove-house, Sutton, Surrey.
Hinds, James, 127, Gosford-street, Coventry.
Jackson, Richard Charles, Grosvenor-park, Camberwell, S.E.
Jekylls, H. H., Lincoln.
Jonas, John J., St. Stephen's Club, Westminster, S.W.
Jones, John James, Brent-house, Devonshire-road, South Hackney, E.
Jones, Joseph, Free Library, Wolverhampton.
Kemsley, Jesse, Rodwell-villa, Rodwell-road, East Dulwich, S.E.
Kidner, William, 23, Old Broad-street, E.C.
Knill, Henry Hughes, 37, Cheapside, E.C.
Leith, J., The Grove, Knowsley-road, St. Helen's, Lancashire.
Littleton, Augustus, Westwood Field, Sydenham, S.W.
Lynam, Henry M., Shelton Colliery and Ironworks, Hanley, Staffordshire.
MacDougall, Robert, 67, Renfield-street, Glasgow.
Marks, David, 4, Cornwall-mansions, South Kensington, S.W.
Molloy, William R. I., 17, Brookfield-terrace, Donnybrook, Co. Dublin.
Moul, Frank, Aldersgate Chemical Works, Southall, Middlesex.
Page, Herbert William, F.R.C.S., 146, Harley-street, W.
Pain, James, Saint Mary-street, Ely, Cambridgeshire.
Pape, Edward James, 67, Great Clyde-street, Glasgow.
Parker, Archibald, Camden Wood, Chislehurst, Kent.
Partridge, Henry Francis, L.D.S., 43, Sussex-place Old Brompton-road, S.W.

Parry, Rev. S. J., S.J., D.Sc., F.R.S., Stonyhurst College Observatory, Lancashire.
Pratt, Benjamin, 1, Wood-street, E.C.
Probyn, Lesley Charles, 79, Onslow-square, S.W.
Rae, George, Redcourt, Birkenhead.
Reeve, William John, Camborne, Cornwall.
Ridgway, John, Heath-house, Cheddleton, Leek.
Rooke, William, 11, Milk-street-buildings, E.C.
Rooper, Thomas Godolphin, 13, Lindum-terrace, Bradford.
Searell, Thomas, Fitzroy, Melbourne, Victoria, Australia.
Shaw, William, 2, Pembroke-road, Kensington, W.
Sherrin, John Vaughan, 3, Codrington-road, Ramsgate.
Smith, James W., Totnes-house, Cawley-road, South Hackney, E.
Stapleton, Edward John, 28, Davies-street, Berkeley-square, W.
Strachey, Sir John, G.C.S.I., C.I.E., 37, Cornwall-gardens, S.W.
Strong, Alfred, 7, John-street, Adelphi, W.C.
Taylor, Henry William, Wallington-cottage, Carshalton, Surrey.
Taylor, William, Hague Bar Board Schools, New Mills, Stockport.
Temple, Thomas Ramshay Smyth, 8, Norfolk-crescent, Hyde-park, W., and Ellerslie, Chichester.
Trotter, William, 24, Prince's-gardens, S.W.
Venn, Charles Augustus, 57½, Coleman-street, E.C.
Walker, Archibald, M.A., 8, Crown-terrace, Glasgow.
Wallace, Prof. Robert, The University, Edinburgh.
Waterer, Clarence, Ingle-cottage, Addlestone, Surrey.
Watson, George Coghlan, Ashburton, Brigstock-road, Thornton-heath.
Whinney, Frederick, 8, Old Jewry, E.C.
Wilkinson, James Herbert, 9, Priory-place, Doncaster.
Wills, Rev. Freeman, M.A., Ferndale-road, Clapham, S.W.
Wiltshire, Ernest William, 25, Granville-park, Lewisham, S.E.
Wiltshire, Rev. Professor Thomas, M.A., 25, Granville-park, Lewisham, S.E.
Wormald, James, Woodville-road, Cathays, Cardiff.

The CHAIRMAN delivered the following

ADDRESS.

You are aware that it is one of the rules of the Society that the Chairman of the Council, at the Opening Meeting of the Session, should deliver an address. Of recent years, at all events, it has been the practice for those who have held the office which I have now the honour to occupy, to select some subject with which they were specially conversant: and, to go no further back, we have had from Sir William Siemens, from Sir Frederick Bramwell, Sir Frederick Abel, and Sir Douglas Galton, addresses of extreme interest and importance. I propose this evening to address to you some remarks on a subject with which I myself am familiar—the Industries of Ireland.

The subject is one which affords a very wide scope for discussion, and it would be obviously impossible to deal with it exhaustively, or with anything approaching to complete detail, in a paper like the present. My object, however, will be accomplished if, in a brief review of the present industrial condition of Ireland, I am able to present to you some of the more hopeful aspects of the situation, and to indicate, in what I trust may be a not altogether unpractical manner, some of the lines upon which I think we ought to proceed in order to take the fullest advantage of the present opportunities.

It would seem to be generally admitted by those who have made it their business to study the question, that now is a favourable time for the Government to intervene in the interest of Irish industries. There is a *consensus* of opinion respecting this point on the part of all who have of late written or spoken upon the matter. More than this, I do not think I exaggerate in asserting the existence of a feeling on this side of the water that England owes Ireland something by way of reparation for that political action which in years past went so near to strangling her manufactures, and did actually destroy her woollen industry.

The Irish sections of the Glasgow, Edinburgh, and Manchester Exhibitions, and the recent Irish Exhibition just closed at Olympia, have called popular attention to the nature and exigencies of industrial enterprise across the Channel, and have shown the world at least this—that in certain departments of art and manufacture Irish men and Irish women can produce first-class work.

The great and critical problem then arises—Can they be made to produce this work on a scale which will eventually and permanently benefit themselves and raise their condition? Will they be able to compete on a commercial basis with neighbouring countries? In a word, is there a prospect of Irish industries directly or indirectly paying?

Now, I have no exaggerated belief in the practical result of mere exhibitions. People come to these shows very much as they come to a bazaar; they buy, perhaps, a few Irish

handkerchiefs, or a few specimens of Irish lace, or what not, just "for the good of the house," so to speak, and they think they have done their duty.

Perhaps they have, from one point of view, and it must certainly be admitted that the public at the present time lead more or less of an exhibition-haunted existence. But according to my conception of the case, Irishmen do not come, like the applicants at a bazaar, suing *in formâ pauperis*. They do not claim for their country, or for their industries, or for themselves that they should be maintained and subsidised as a mere interesting though expensive illustration that something can, after all, be produced in Ireland. They do not ask, for instance, that compressed Irish peat should be used in their furnaces, simply because it can be so used, when it is proved that Scotch coal will do the work more cheaply, and with equal effect. But they do claim that their many possibilities of successful industry should obtain from the State a fair and substantial amount of encouragement; and they say, moreover, that they believe that these industries so subsidised have at least a fair chance of ultimately paying. Now we all have our own opinions upon these matters; some of us are pessimists and some of us are optimists, but for myself, I frankly say that I belong to a third party, and do not rank myself under either of these denominations. Now, I for one, do believe in the capacity and talent of Irish men and Irish women; but at the same time, I must state my opinion that, where a poor country like Ireland, with undeveloped industries, stands near one with great wealth, and industries highly developed, there seems no possibility of the extension of the industries of the poorer country, except by a period of cultivation and nurture.

Political economists may argue, and I daresay with force, against this proposition, but I am speaking of no abstract conception of a perfect polity, of no fabled island of Sir Thomas More, of no "New Atlantis" of Bacon, but of the Ireland of to-day, that "island surrounded by a melancholy ocean," with all its wants and woes. As I have just said, I am neither pessimist nor optimist as regards my country, and if I were asked to sum up in a single word my ideas of the change I might fairly hope to see in her condition during my own time, the term I should use would be, not revolution, not metamorphosis, but amelioration.

Now I know very well that English sympathy is largely enlisted at the present day on behalf of Ireland. Politics apart, there is a general and generous wish to know and to deal with the desire and exigencies of the sister isle, and accordingly it seems to me to be both the privilege and the duty of those whose lot is cast amongst the Irish to do what in them lies towards the great purpose of showing how her people may be socially and materially benefited.

There is always a good deal of adverse criticism in vogue against Irishmen; though not so much, I am happy to say, as was formerly the case; still we often hear the reproach, "Ye are idle, ye are idle," cried out by persons who, whatever their intentions may be, do not always measure their language by their knowledge of the subject.

Do not suppose that I am a general apologist for that lack of business persistency and punctual work which is often too prevalent amongst our people, but neither do I lose sight of the fact that it is as difficult, say, for the Donegal fishermen, without proper boats, nets, and equipments, to take an adequate haul of fish, as it was for the Israelite of old to make his tale of bricks out of the stubble; but the method and expectations of Pharaoh, however they may have been fulfilled on the banks of the Nile, have certainly not met with success on the Atlantic sea-board of Ireland.

Now, unfortunately, Ireland is a poor country, and one mainly dependent upon agriculture. No doubt in the great and thriving province of Ulster there is the flax and linen trade, and this may fairly be called a large industry in relation to the province, though it can scarcely be so termed in relation to the country at large. Still the fact that this profitable, independent, and prosperous trade exists in Ulster should make us hesitate before assuming that the atmosphere of Ireland is necessarily fatal to the establishment of large and successful industries. I have not been able to find any definite evidence to show that the climate, the soil, or the general conditions of the rest of Ireland are unfavourable to the growth and manufacture of flax. The northern province does not owe her prosperity to any special climatic or physical advantages; she owes it to the indomitable energy and industry of her population.

Of the flax trade in Ulster I shall have more to say later on; but we should remember that it is not to any bright particular star that our attention should be directed; our view should

as far as possible comprehend the whole of the horizon, with all its shadows and its clouds. Well, then, as I have said, Ireland is admittedly dependent upon agriculture. That industry is at present in a depressed condition, and the consequence is that in the populous districts the people are unable to subsist in anything approaching to comfort unless they are enabled to supplement their only industry by some other means. You see the surplus agricultural population in Ireland is in a very different position from that of England or Scotland. In the last countries this surplus is attracted to the great towns where there is plenty of capital, and where, owing mainly to the mineral wealth of these more favoured lands, the people have taken to manufactures, and the factory system flourishes.

How real this difference in the position and opportunities of the people is, may perhaps be most forcibly conveyed by reference to a few statistics. It has been estimated that in England agriculture supports 13·2 per cent of the people, in Scotland, 14·0 per cent., while in Ireland no less than 49·5 per cent. are dependent upon this industry. When I add that the per-centage of the people of England and Scotland who support themselves by manufactures is roughly estimated at 33 per cent. and 30 per cent. respectively, as against 16 per cent. in the sister isle, you will have no difficulty in realising the poverty of Ireland in these departments of industry. I do not intend to trouble you with too many statistics, but in order to obtain a comprehensive view of the occupations of the people of Ireland, I have availed myself of a short Table taken from the interesting and suggestive address of Mr. Carbutt, the President of the Institution of Mechanical Engineers, delivered in Dublin last August. This Table divides the population under six heads, and compares the years 1871 and 1881, with the following results:—

Occupations.	1871.	1881.
Professional	152,860	198,684
Domestic	740,195	426,162
Commercial	105,619	72,245
Agricultural	1,062,008	997,456
Industrial	538,135	691,509
Indefinite and unproductive	2,813,560	2,788,281

This Table of statistics given in connection with the preceding figures affords you a general view of the Irish population and their employment as contrasted with that of England and Scotland. When one comes, however, to examine into the manufactures of Ireland, it is exceedingly difficult to arrive at any exact estimate, owing to the fact that no account of the export and import trade is kept. I do not mean that each seaport may not keep a record of its own export and import tonnage, but there are certainly no Government returns available dealing with the country as a whole.

I will now, with your permission, consider in a little more detail some of our existing industries, and I shall first briefly notice the great lucrative and self-supporting linen trade of Ireland, which is in itself a living monument to the enterprise and industry of the northern province, and whose practical results constitute the one really hopeful and luminous break in our commercial horizon. This trade is conducted principally in and around Belfast, and is almost exclusively confined to the province of Ulster. There are 60 spinning mills, containing 843,590 spindles; and 60 weaving factories, containing 27,300 power-looms; making in all a total of 120 concerns.

These establishments give employment on their premises to 61,749 workers, of all ages and sexes, and pay about £1,250,000 per annum in wages. It is estimated that they necessitate the employment of £18,000,000 sterling capital, a large proportion of which is fixed in plant, buildings, and machinery. The figures I have given only represent the linens and yarns in their brown state—that is to say, as they come off the spindles and looms, and beyond this, the ulterior process of preparing the goods for the market—such as bleaching, dyeing, printing, ornamenting, and packing—employs fully as many hands—say 60,000; and pays a higher rate of wages—say £1,500,000 per annum. The capital employed at this end of the business it would be impossible to estimate. The spinning mills use about 20,000 tons of foreign flax and tow, value about £750,000, and about an equal quantity of Irish flax per annum, grown principally in Ulster, and valued at a million pounds sterling. This million of money will find its way into the hands of about 48,000 farmers or flax-growers, and gives rise to a rural industry in Ulster of 1,055 scutching mills, paying annually about £90,000 in wages.

The linen trade of Ireland participated fully in the great depression of late years, and I find, by a comparison of the declared value of the export of the chief primary articles of British and Irish produce for the nine months ending September 30th, 1888, and the corresponding nine months in 1887, compiled from

the Board of Trade returns, that it has hardly yet felt the improvement so manifest in some of the other great exporting industries.

These statistics, the accuracy of which I can vouch for, speak for themselves, but one must have known to realise in full what the establishment of one of these great concerns in a district means. In my own immediate neighbourhood, in the county of Tyrone, I have frequent opportunities of observing the local effect of the splendid flax mills belonging to the enterprising proprietors, the Messrs. Herdman, which give constant employment to close upon 1,100 hands of all ages and both sexes. Messrs. Herdman pay annually wages to the amount of £27,000, and work up Irish flax to the value of £90,000 a year.

Consider what this means to the poorer class of farmers and labourers in the district, where small boys and girls can supplement the slender resources of the family to the extent of 10s. and 12s. a fortnight. During the bad times which have prevailed of late, these mills, with their whirring looms and clustering village of neat operatives' cottages, have constituted a veritable oasis of prosperous industry in the midst of the desert of comparative agricultural depression. I may mention here that the Belfast Technical School has been most successful in training its pupils in the cultivation and spinning of flax.

From the consideration of this bright and attractive subject of the Ulster linen trade, let us turn to the consideration of another, and one which certainly ought to be an Irish industry, but which unfortunately does not exhibit the same encouraging features, I mean the deep-sea fisheries. Now it is beyond all question that there is a vast harvest of fish waiting to be gathered round the coast of Ireland, and more especially off her Atlantic sea-board. Mr. Alfred Harris, in his interesting notes made during a tour in 1887, tells us that in and around the neighbourhood of Baltimore during the spring fishing season, instead of the natives catching the fish themselves, and securing the profit on the sale of them, they act chiefly as entertainers to the foreigners —Manxmen, Frenchmen, Scotchmen, Cornishmen, and others—who come in thousands to reap the harvest of these Irish seas, and to transport it to the English markets, or to places where it can be salted and preserved for foreign exportation. Now, unfortunately, Baltimore is no exceptional instance of the discouraging but, I am sorry to say, indubitable fact, that in Ireland deep-sea fishing is a declining industry; for whereas in 1846 nearly 20,000 vessels, manned by 115,000 men, were employed in the fisheries, there are now but 5,683 vessels, manned by 21,500 men, so engaged, and more than this, according to Mr. Carbutt's estimate, only some 4,000 of these are wholly engaged in fishing. How is this to be accounted for? Well, I am sorry to say the reasons are obvious enough. The Public Works Commission, in their report, declare (1) that the appliances used in Ireland for deep-sea fishing are miserably defective; (2) that there are in the whole of Ireland only 600 boats above 30 feet keel; and (3) that many of these vessels are undecked, and consequently unfit to go to sea in rough weather. They further report that there are no curing establishments, and that none of the nets are made in Ireland, and express their opinion—in which I must say I entirely agree—that the only chance for deep-sea fishing to be profitably carried on as a national industry lies in the construction of a certain number of harbours, containing a sufficient depth of water, for the accommodation of fishing boats of all dimensions at low tide; and they go to the length of recommending the Government to spend £400,000 in the construction of such harbours.

It seems to me that there are several schemes and suggestions in connection with the deep-sea fisheries which are, at least, worthy of consideration. There is no doubt that, even in favoured spots where the harbours are fairly good, Irish fishermen, when they are so fortunate as to take a good haul of fish, are tremendously handicapped, first of all, by the absence of means of transit by land; secondly, by the high railway tariff where such a means does exist; and, thirdly, by the absence of regularly attending and swift-going steamers for the purpose of transporting by sea to the English and foreign markets. Well, I have heard it suggested in some quarters that there should be a large extension of railway communication with the harbours and fisheries of the western coast, and that a system of moderate tariffs should be enforced upon the companies; I confess, for myself, that I have little faith in such a scheme, nor do I see, having regard to the enormous outlay which would be entailed by running lines to the remote recesses of the Irish coast, that anything approaching to fair ultimate return, on any sort of commercial basis, could be

looked for. I do not say that where a fishing centre is separated by a short or even a considerable distance from some existing line, it may not be worthy of consideration whether a junction might not be effected with some prospect of success. For instance, I know that some people who have given attention to the question are in favour of uniting Killibegs to Druminin, the present terminus of the Donegal light railway, a distance of, I believe, some 18 miles. Killibegs, I may add, is one of the finest harbours in the world, and is open in all weathers to the biggest of any of her Majesty's ships of war, and would make an admirable central fishing station. My remarks are intended to apply to any large or general extension of the railway system in the poor and backward districts of the west of Ireland. Any such enterprise would inevitably result in a series of individual failures, the cost of which would ultimately have to be borne by the British tax-payer. It is quite enough to ask this patient body to help a project whose success is doubtful, without calling upon it to contribute funds to a scheme whose failure is a foregone conclusion.

Of course, in the event of State purchase of Irish railways, I might have to qualify these remarks to some extent. Presumably the direction of new branches of railway line would then be under competent, skilled, and responsible supervision; the railways might then, if I may so express myself, feel their way out coastwards, and so really develop and assist the population of these parts. At present no great parent line is making any extension; the light railways are promoted and capital is provided by private companies. The local authority (the grand jury of the county) gives a guarantee for interest on the capital, and if the county guarantee is called for, the Treasury is to repay the county half the amount it had paid on account of any half-year's working, provided the line was kept in order and has carried traffic. But then the gauge of these lines is fixed, so that they differ from the gauge of ordinary railways, compelling the shifting of goods and passengers at each point of junction. Consequently the existing companies refuse to work the light or narrow-gauge lines, and the project on the whole can hardly be called a success.

I confess in this connection I am inclined to agree with Mr. Adamson, in his speech at the reception of the Institution of Mechanical Engineers at Trinity College, Dublin, where he says "that he believes water to be the carrying power of the future, and that if Ireland was to look for anything to improve her position, it must be by getting a universal outlet all round the island for her produce at the lowest possible rate, and sending it into the great consuming centres, like Manchester where everything they could produce was wanted if they could only send it cheap enough."

I am of opinion that the only possible way to develop the fisheries of the Irish Atlantic seaboard is by the creation of suitable and convenient harbours; by enabling the fishermen to supply themselves with boats of over 30 feet keel and over 30 tons burden; by helping them to establish store and curing houses, and, above all, by supplying them with technical education in those branches of the craft and trade connected with net-making, boat-building, and the curing and preserving of fish. I would lay great stress upon the necessity of providing boats of adequate size, such as I have mentioned. Any one who has stood upon the cliffs of West Donegal, or on the iron-bound coast of Arranmore, and seen—even on a day when there would be nothing to disturb the tranquillity of our more protected seas—the huge Atlantic rollers thundering against the shore and through the caves, can imagine the position of the native fishermen in their wretched craft, with the same sea running mountains high before a gale from the north-west. It is, indeed, admitted by everyone who has studied the matter, that the present craft, even if manned by the most courageous and experienced English or Scotch fishermen, are quite unsuitable and inadequate for the Atlantic fisheries.

I know that this is rather a comprehensive programme which I have submitted, and I know, too, that the only chance of its ever being carried out, or even fairly tried, depends upon liberal and substantial encouragement on the part of the State. Voluntary or individual effort unaided is quite unequal to the task. I am well aware, moreover, that it is an experiment upon a large scale, and that the question of its ultimate and complete success is at least a matter upon which a man may fairly feel doubtful. You see, assuming that we have our harbours, our boats, our tackle, our steamers, and all necessary equipment, our fishermen have still to compete with the trained, experienced, and hardy fishermen from Cornwall

and elsewhere, who are scarcely likely to enter into the spirit of our scheme to the extent of abstaining from fishing those waters whence they have hitherto obtained so abundant a harvest. Still, after giving the subject the best consideration in my power, I believe the Government would do well to take action upon the lines I have indicated. The experiment initiated by the Baroness Burdett-Coutts, who was so ably and indefatigably seconded by Father Davis, whereby money has been advanced to the fishermen of Baltimore, for the purchase of boats, nets, &c., to be repaid by them in small and easy instalments, has, so far as one can judge of an infant enterprise, proved eminently successful. The liberality to the fishermen of Baltimore on the part of the Baroness was supplemented by Father Davis in the following manner. He saw that to enable the district really to take advantage of its present good fortune it would be necessary to teach the rising generation to compete with the foreigner in various ways; he accordingly resolved to start a school in which all the fishing industries should be taught in an efficient and practical manner. He required the large sum of £6,000, but in response to his appeal obtained considerably more. The grand jury of the county granted £1,000, nearly £3,000 was raised by subscription in Ireland and England, and the Treasury, through the Irish Executive, has added a donation of £5,500. Mr. Carbutt states that the inhabitants of this one village, who might have been previously described as chronic mendicants, are now in a relatively prosperous condition. I cannot but think that this instance goes far to justify the conclusion of Mr. Harris when he says, "In the work in progress at Baltimore we have a test case of the principle which I have advocated, viz., that a combination of voluntary zeal and work, with assistance from the State, is capable of leading to great results."

Just think what one of the practical results of such a school might mean to the people of a village like Baltimore even in one simple elementary branch of industry, when Father Davis states that in the year 1887 one Scotch firm had sold in Baltimore £3,000 worth of nets in a single day!

I am indebted to Sir Thomas Brady, H.M. Inspector of Fisheries, for the following account of the present condition of these schools. "We have 75 boys," he writes, "all at work at fishing industries which must in the end tell over the entire coast. We shipped 171 barrels of cured mackerel for America last week, and are hard at work curing more. Our boys have now got quite handy at it, and also at mending nets, &c."

Some people are given to express an unduly depreciatory, and, as I think, ignorant opinion of Irish fishermen. I have some personal knowledge of the coast population, and the result of my observations has been that if a somewhat primitive, they are, upon the whole, physically and mentally, a fine and intelligent race; they are peaceable and law-abiding, comparing very favourably with the inhabitants of the poor and mountainous inland districts; and this description I should also apply to the dwellers upon many of the islands off the coast. That these people are able, upon occasion, to outwit in business acumen their more civilised neighbours upon the mainland, is illustrated by an anecdote told me during my visit to Tory Island, off the Donegal coast, last summer.

A native lady—I don't know whether she was of the blood-royal, but it is only within the last few years that the Tory dynasty of kings has become extinct—found it necessary to call in medical aid. There is no resident doctor upon the island (and I was assured that there had been, out of a population of 300, only one death during the last three years). The gallant islanders accordingly embarked for the mainland, and interviewed the doctor. The man of medicine not unreasonably declined to trust himself to the elements, with nothing between him and the Atlantic except the canvas bottom of a Tory boat, until he had received the usual fee of a guinea. To this, after considerable demur over what they considered to be an exorbitant charge, the islanders finally assented, and a successful landing was effected upon the island. The doctor saw the lady, whom he treated with the most satisfactory results, but upon expressing his desire to be conveyed to the mainland, was respectfully, but firmly, informed that he could not make the return journey without the payment of their fee, namely, two guineas. The unhappy gentleman protested, but Charon was inflexible, and he was eventually taken home, a sadder and more experienced man. I am afraid the action of these islanders is calculated to discourage medical enterprise in the principality. Of one thing, at all events, I feel pretty confident, that if, in the course of the next year or so, another prince should come to be born on Tory Island, the doctor will make a more business-like

and specific agreement with these primitive islanders before embarking upon a second cruise.

I was much struck when on this island with the desirability of establishing telegraphic communication with the mainland. It is often, I am assured, the case that on outlying stations such as Tory, Achill, or Arranmore, the presence of shoals of fish can be detected in various ways, but there is at present no means of communicating the fact to the harbours and fishery stations of the mainland. The advantages which would accrue from so prompt a means of knowledge of the whereabouts of the fish to the native fishermen of the mainland is obvious.

I would also suggest that skilled officials should draw out, and from time to time correct and revise, a chart showing the positions and shiftings of the various fish-banks upon the coast; and also that a steamer should be placed at the disposal of the inspectors of fisheries, or whoever the officials might be who were entrusted with the supervision of the scheme. There is no such vessel at the disposal of the present inspectors, and o ask a nation possessing the greatest fleet of steamers in the world to supply this patent defect seems to be certainly not unreasonable.

As a similar though alternative suggestion to this last, I would propose that two first-class sea-boats, steamers of some 200 tons each, and capable of making ten to fifteen knots, be supplied and fitted out for one year's service with the best procurable fishing gear of all descriptions. The estimated cost of each vessel is £5,000.

They should be under Government supervision, but commanded by the most experienced and skilful master-mariners the district could produce, and manned by the best local fishermen. I should place one upon the west, and the other upon the north-west coast. The duty of these vessels would be, during the winter months and in all weathers, to remain upon and fish the various banks where cod and ling abound, and whose average distance from the coast is from forty to seventy miles. Having obtained full cargoes of fish, they should at once steam full speed to the nearest harbour, or the nearest place where a good market can be obtained, unload and return to the grounds. This experiment should be repeated along the entire coast, and, of course, an accurate account of expenditure and profit should be kept. By this means a dual result will be obtained.

(1) The very best banks for deep-sea fishing will be found out by exhaustive experiments.

(2) The nearest and most suitable points on the mainland, either for constructing harbours or for tapping by railway, will be ascertained.

If loans such as I have spoken of were made to the fishermen, it would be necessary to inaugurate some system of place to place attendance, for the purpose of collecting the instalments as they fell due. Possibly it might be found feasible to utilise the coastguard for this purpose. I have dwelt at such length upon this deep-sea question because I honestly believe it is one in respect of which we have a fair claim upon the liberal consideration of the Government, and I am glad to observe that Mr. Balfour, in his recent reply to the deputation of the Irish Home Industries Association, declared that the Government were "pledged to carry out a very large scheme for Ireland, resembling the recommendation given by the reports of the recent Commission on piers, harbours, railways, drainage, &c.;" and the Chief Secretary adds, "I hold that it is the business of the richer parts of the United Kingdom to aid the poorer parts, especially when the poorer parts owed their position to the selfish legislation on the part of the Government during the last century." Remember, ladies and gentlemen, that the Scotch fisheries were assisted by large grants from the Government, until their position was secured. Bearing this in mind, when we find that in 1886 the estimated value of fish taken in the Irish waters amounted to but £64,000, while in Scotland it amounted to £1,397,000, and in England to upwards of £4,000,000, I think a very strong *prima facie* case is made for seeing whether analogous treatment as respects the Irish fisheries would not produce a similar result.

There is one consideration arising out of this subject which presses very strongly on my mind. As long as this great coast population remains dependent upon its miserably inadequate agricultural resources, it must be a constantly recurring source of embarrasment to any Government, I care not what its form may be. There is no magic in any change of legislation which can alter the climate or the soil. "Good heavens!" exclaimed Carlyle, forty years ago, "extension of the electoral suffrage! what will that do for a country that labours under the frightfullest immediate want of potatoes?"

I do not believe, although no doubt great numbers of these poor people are at present

emigrating, that they will ever voluntarily leave the country in sufficient numbers to allow those who remain to exist in comfort so long as they are mainly dependent upon their holdings; and even if it were desirable, any system of compulsory emigration is quite out of line with the tendencies of modern legislation. For this reason, such a relief and encouragement scheme as I have endeavoured to present you with the outline of, affecting not only the fishermen themselves, but establishing a large subsidiary coast industry, even if we should not, from a strict commercial point of view, repay the whole, or even a considerable part of the outlay, would nevertheless be indirectly profitable to the State. For though a Government might possibly justify itself, on commercial principles, in refusing its aid, it might be bad economy after all, because no civilised Government, under any circumstances whatever, or according to any principles, can afford to allow any portion of its people to starve.

With regard to great private industrial enterprises, I do not intend to more than notice the great establishments of Guinness's porter brewery in Dublin, and the great ship-building and marine engine works of Wolf and Harland in Belfast, I suppose the most extensive concerns of their nature in the world. With respect to the former, the public estimation in which it stands is tested by the regret which most of us feel that we did not become early possessors of more shares in that great company. Regarding the latter, some idea of its progress may be obtained from the fact that in 1858 their works employed only 100 hands, whereas they now employ 5,000, and have two steel ships of 10,000 tons each on hand. As a further instance of the enterprise of Ulster, I may mention that Mr. Biggar, a worthy native of that city, has started a spacious ship-building yard in Londonderry, and the clang of the hammers and the noise of the machinery warns those who were so unfortunate in the past as to select residences in the neighbourhood that the industry threatens to become so prosperous as to drive them without the ambit of its din. As regards this ship-building yard in Derry, it seems to me to be a most powerful illustration in its way, of the principle that give an industry a fair start in Ireland it may do well. The Harbour Commissioners in Derry were enabled by Act of Parliament to apply certain of the dues which they collected to the establishment of a ship-building yard with its premises and conveniences in their port. It only remained to find someone with sufficient enterprise to avail himself of the opportunity of taking these premises, and Mr. Biggar has done this with the results I have noticed. He has now four ships on the stocks, besides the fact that he has already turned out several vessels, and a prosperous industry, with all its present accompaniments and future possibilities is established. He now actually brings over iron material and necessary stuff from Glasgow, which is worked with a profit in the yard. Every credit is to be given to Mr. Biggar for his enterprise, but it is pretty certain that without these enabling powers conferred upon the Commissioners we might have gone far into a future century before seeing a ship-building industry in Derry.

With respect to our mineral wealth, one realises how small it is by the fact that only some 3,000 odd men are employed in it. There are only about 100,000 tons of coal raised yearly, and that for the most part of an inferior quality, while about the same weight of iron ore is annually obtained. The copper and gold mines of Wicklow have gradually languished into decay, and beyond completely poisoning what would otherwise be a good salmon river, they in no way affect the condition of the country. The lode or strain of valuable metal in the Irish mines seems to be so sparsely distributed that as a rule the working of the ore does not repay the cost of labour. There may be, and I hope there is, a future for Irish mines, but researches up to the present have not been hopeful. I know that years ago a silver mine was started upon my own property, and silver and lead were ascertained to be present in a considerable quantity; but either from the proportional scarcity of the metal, or from the stubbornness of the material in which it was found, the enterprise came to a speedy determination.

In reference to the mineral resources of the country, I should not omit to make mention of the beautiful marble and granite that are to be found on the west coast. Though these are worked to some extent, they are not used to anything like the amount they would be if more capital were available, and if there existed better railway communication in the neighbourhood of the various quarries.

It is the absence of any appreciable supply of steam-coal that forms, in my mind, one of the strongest arguments against the feasibility of establishing factories throughout Ireland

upon any large or general scale. If a manufacturer can get coal, say, at 8s. per ton for his engines in Lancashire, he would probably have to pay 14s. for it in Dublin, and a good deal more in the remote parts of Ireland. Water power is quite too uncertain to be relied upon without supplementary steam in carrying on a large concern. Now, in establishing such factories, we should certainly in the vast majority of cases require English and Scotch experts and capitalists to start them. Would such men be likely to play so hazardous a game when, at places like Bradford, Macclesfield, or Manchester, woollen, silk, and cotton mills are scarcely able to hold their own?

These considerations bring us back to the fact which I have endeavoured to face all along, viz., that Ireland is mainly dependent upon agriculture. You will find—I am, of course, speaking generally—that if we except the various self-supporting industries in the province of Ulster which centre in the factories of Belfast, Lurgan, Bangor, Portadown, Londonderry, Lisburn, Newry, and Strabane, that most of the rest are in more or less a languishing condition, or at all events, can scarcely more than hold their own. The great shirt trade, which centres in Londonderry, gives occupation to 10,000 hands, one fourth of which are employed in their own cottages; and in the handkerchief trade, which centres in Lurgan, some 10,000 women find employment. All these industries, together with sewn muslin and embroidery, according to Miss Helen Blackburn, bring work into nearly every cottage in the greater part of Ulster; and she further states that, "in Donegal, when, in 1880 and 1881, the labourers returned from their usually remunerative expeditions to seek harvest work in England and Scotland, it was the needles of the girls that kept starvation at bay." I do not wish for a moment to set up my authority against Miss Blackburn, or in the least to minimise the great and far-reaching blessings conferred by these industries; but I venture to think that just that one phrase about "nearly every cottage over the greater part of Ulster' (I shall be delighted to be corrected) is a little too comprehensive.

Perhaps I should here more definitely mention, under the head of sewing and embroidery, the industry carried on in the county of Donegal, and also in considerable districts in the counties of Derry and Tyrone, in the exercise of which girls are entrusted with the most costly materials on behalf of large London houses; I believe that over £20,000 is annually paid into these districts in respect of this single industry. Excellent and admirable work is done in this line in the way of preparing young ladies' trousseaux, and all the various embroidery and art incident to the perfection of the many interesting and elaborate garments, into the details of which, however, I do not feel myself competent to enter. It has been suggested to me, in connection with this branch of industry, that some sort of co-operative system might with advantage be adopted by the workers, through which they might come into more direct communication with the market, and so avoid the loss entailed by sending their work through middle-men and middle-women to such market.

I do not say that this idea is necessarily unpractical or unworthy of consideration; but for my own part I should hesitate to interfere with the *régime* of a branch of industry which has worked well in the past, and is at present in a prosperous condition. It must be remembered that these middle-women are to a great degree the pioneers of the industry, and, as in the case of the Misses Scott, of Castlefin, co. Donegal, they are generally practical and skilled workwomen, whose name is a sufficient guarantee to the houses which employ them that the work transmitted through their agency will be of a thorough and first-class character.

I should not leave this section of my subject without alluding to the woollen trade, which is naturally a staple and historical grievance in the commercial history of our country. The woollen trade was introduced into Ireland before the restoration of Charles II., and subsequently grew into a prosperous industry, but as its success in Ireland tended to lessen the export of wool to England, the manufacturers in that country obtained legislation to impose such heavy taxes as to exclude the manufactured article from the English market.

Speaking of this selfish piece of legislation, Swift says, "At the passing of this fatal Act the condition of our trade was glorious and flourishing, though in no way interfering with the English; we made no broadcloth above 6s. per yard, coarse druggets, baize, and shalloons, worsted damasks, strong draught works, slight half works and stuffs were the only products of our looms; these were partly consumed by the meanest of our people, and partly sent into northern nations, for which we had in exchange—timber, iron, hemp, flax, tar, and hard dollars."

After the year 1782, the Irish Parliament adopted measures for extending manufacturing industries, and at the present day this industry is kept alive in 14 counties, viz., Dublin, Cork, Down, Waterford, Kilkenny, Wexford, Queen's County, Meath, West Meath, Kildare, Fermanagh, Clare, and Limerick. There appears to have been a decrease in the number of factories from 1839 to 1850, since which time a certain number of the discontinued factories have been re-occupied. The total number of factories is now 47, but in only two of the counties, viz., Cork and Dublin, does the number of hands exceed 100.

The total number of persons employed in 1881 in wools and worsted manufactures was 7,710, as compared with 20,762 in 1871.

Many of the Irish tweeds are of excellent quality, pattern and durability, but for some reason they seem to lack that peculiar softness and flexibility which we find in the English and Scotch materials. I speak under correction, but I think it is quite the exception on a market day in an Irish country town to see anyone, except perhaps the much-abused Irish landlord, clad in the manufacture of the country. Many farmers will no doubt be dressed in homespun, but that is the product of the lingering cottage industry, and not of the factory.

I now come to the very interesting subject of what are termed Irish home industries. The object of those whose views are represented by the Irish Home Industries Association, is the development of cottage industries at present existing, the revival of some of those which have fallen into disuse or depression, and the incorporation of an extended system of technical education throughout the country. They rely upon the fact, and a fact it certainly is, that agriculture, which is at present the only large industry, is in a depressed condition, and can no longer, unaided, support the present population in the congested districts in comfort; and Mr. Arnold Graves goes on to observe that "Parliament has shown its readiness to expend vast sums of money, with the object of developing a peasant proprietary in Ireland, but unless the children of our peasants receive a training suited to fit them for industrial life, they must continue to spend a great part of their lives in enforced idleness, instead of in profitable occupation, and the State will have made its sacrifices in vain."

There has certainly of late been a laudable exhibition of interest on the part of many philanthropic people, on behalf of these home industries, and the resources and possibilities of the country have been impressed and urged upon the public with great energy and zeal. Mrs. Hart, whose initiatory efforts have been greatly facilitated by the advantage of previously existing industries, has directed her efforts to raising the quality of the work produced, to teaching the women the art of dyeing on scientific principles, and men that of weaving on improved looms, according to new and various patterns. Through energy and perseverance, she has obtained a grant of £1,000 from the Government, for village technical teaching in county Donegal. It must be remembered, however, that private and philanthropic effort is not a thing of yesterday in Ireland. For many years past, throughout the greater part of the island, numbers of persons, and especially ladies, have worked hard, sparing neither time, labour, nor expense in their endeavour to raise and better the condition of their poorer fellow countrymen and women. Among others, the following names are associated with the good work — Mrs. Hall Dare, Mrs. Bagwell, Mrs. Sinclair, Miss A. Goold, Miss Fitzgerald, Miss Roberts, Miss Keane, and Miss Tottenham. These efforts have been by no means without result, but owing to various reasons—the competition of machinery, the lack of organised means for discovering and procuring regular markets, want of system, lack of funds, often, I fear, an absence of business-like habits and punctuality on the part of the workers themselves, and, above all, to the fact that many useful works have been started on charitable instead of commercial principles—the results, as a whole, have not been commensurate with even very moderate expectations.

Well, it is urged with great force that now is the time, while cottage work has still a place, to preserve these handicrafts by good teaching power. "Permanent skilled teaching power," says Miss Blackman in her interesting paper on "Irishwomen's Industries," "is the first great need, and the second is organised production and distribution." I cannot attempt, in the time at my disposal, more than to glance at one or two of these cottage handicrafts; but it may interest you to know how various a schedule has been received by the Irish Industries Association of the industries actually in existence. That useful and carefully compiled "Book of Reference for Irishwomen," by Miss Blackburn and

Mrs. Power Lalor, gives it as follows:—"Lace making, handloom weaving in linen and wool, machine weaving in the same fabrics, hand-sewn underlinen, hand-knitting of every kind, embroidery, linen and wool-yarn spinning, flannel and freize weaving, linen and muslin weaving, cambric weaving, wood carving, sprigging, bonnet covering, horse-hair work, crochet work, tatting, wool and yarn dyeing, wool carding and spinning, pillow-lace making, silk spinning and silkworm rearing, straw plaiting, straw-mat and chair making, crewel work, dress making, basket making, tobacco-pipe making, earthenware manufacture."

Now the greater part of these industries are entirely worked by women, and a pleasant feature connected with them is that they involve no element of the sweating system. The women work them in their own houses, at the cottage door, or, perhaps, upon the hill-side, in the healthy mountain air. Nothing is more common in the neighbourhood of the Donegal highlands than to see young girls engaged in herding the small mountain cattle, at the same time busily engaged knitting, and even if they earn only a few shillings a fortnight, how immeasurably better to be thus employed, than in lounging aimlessly about, or in crooning over the turf-fire, without interest, or object, or hope. This knitting industry has been established in various parts of Ireland. In Valentine Island it was founded by Miss Francis Fitzgerald in 1880, at the Rosses, co. Sligo, by Miss Roberts in 1882, and at Althea, co. Limerick, it is now being actively developed by Miss A. T. Goold. Knitting also flourishes to a very large extent in Donegal. Having been originally inaugurated upon a somewhat restricted scale by Lord George Hill, it was taken up by the late Mr. Daniel McDevitt, of Glenties, whose knowledge of the country and whose business instincts enabled him to go largely into the trade which has since spread itself over North Donegal, and which figured so creditably at many stalls in Olympia during the present year. Much of this knitting is of a highly skilled nature, and it is satisfactory that it exhibits all the signs of progressive improvement. I have myself personal knowledge of the beneficial effects of these knitting industries, as I have established one upon a small scale at my own place in Ireland, for the benefit of the poorer class of peasants in the neighbouring districts. The Duchess of Abercorn found the funds, which my steward's wife invested in buying the yarns and needles. The clothing department of the British army looked favourably upon the enterprise, the result being that some 20,000 pairs of socks were sold in a single year. The girls are paid according to the weight, quality, and size of the goods, and many of them come in from three to eight miles to avail themselves of the chance so afforded.

During the years 1886-87 some £5 per week were regularly paid out in wages, and, owing to the progress of the industry, the amount for the current year has been much larger.

There you see employment is given to the daughters and wives of 300 poor labourers and petty farmers of the district, who are now enabled to add substantially to the family comfort, but who otherwise would simply be sitting twiddling their fingers at home. But good as many of these industries are, and hopeful as may be their prospects, the condition precedent to any possibility of their ultimate and general success is that they should be placed upon a commercial basis, and this fact the advocates for Government support and encouragement recognise in the fullest degree. It is hopeless to look for combined voluntary effort on a large scale at present, and the history of the lace trade—if one required an illustration—accentuates the fact that private effort cannot be kept at a high mark for an indefinite time. It was after the terrible famine, from 1846-48, that a wide-spread endeavour was aroused throughout the kingdom to give the unfortunate peasantry something more than their miserable potato plots to depend upon, by the development of the lace industry; but as there was no organisation to keep the workers in touch with the needs of the market, patterns—as Miss Blackburn expresses it—were copied "in and in," till all their original spirit and form were lost, and the beauty of the needlework thrown away upon useless designs. Thus, as I have said, private effort having no indefinite staying power, and owing to the want of a sound commercial basis, many of these needlework factories wholly disappeared, while in others, as in the case of the lace and crochet at Limerick and Cork, the deterioration was rapid. At the present day there are about twenty-six lace factories in Ireland, bringing in about £5,000. In Munster, subsequently to the Cork Exhibition of 1883, the convent lace schools, Kenmare, Tralee, Kilkenny, Kinsale, Blackrock, St. Vincent's, Cork, Youghal, Thurles, recognising the neces-

sity for improvement of design, put themselves in connection with the Cork Schools of Art, where drawing is taught in connection with the making of lace, and with excellent results. Mrs. R. N. O'Brien has, within the last few years, revived the working of the more delicate kinds of Limerick lace, and those who have seen the specimens of this department of industry at Olympia will be able to appreciate the results of her labours. The lace-workers can earn from 3s. to 14s. per week, and it is an easy, and essentially womanly, industry, involving neither exposure to weather, rough manual labour, or severe factory work. Mrs. Power Lalor reports that the lace industry throughout the country is steadily increasing, and if properly supervised, so as to prevent inferior and bad lace clogging the market, Irish produce will yet prove a staple industry in Ireland. It is certainly significant to learn from the Custom-house returns that lace to the value of over a million pounds is annually imported into Great Britain. Mrs. Lalor thinks there is no reason why this money, or a large portion of it, should not flow into Ireland, and that punctuality, precision, and a fair uniform scale of prices, will bring about this desirable result.

It would be interesting, if I had the time, to glance at the history and possibilities of other cottage industries; but I wish to say a few words upon the practical suggestions which are urged upon the subject, and it seems to me that the two upon which I have dwelt with a little detail, knitting and the lace trade, will supply any practical illustration necessary for its consideration. Now what is meant by technical teaching? I think it has been well defined as "teaching children to use their hands and eyes, and also giving them such practical acquaintance with the applied sciences as may bear upon the industrial employments in their district." The Irish Home Industries Association, in their memorial to the Chief Secretary, have expanded this definition in the following resolutions, which also contain the practical suggestions and the outline of their scheme:—

MEMORIAL.

2. That the kindergarten system should be more widely taught in our National schools, and that the results fees for teaching according to this system should be made sufficiently large.

3. That this system should be continued so far as possible throughout the primary as well as the infant school course.

4. That writing be taught in connection with drawing.

5. That arithmetic be taught with practical illustrations.

6. That in elementary schools all girls should, so far as possible, be taught plain cooking, plain sewing, and cutting out; and that all boys should be taught drawing and manual instruction.

7. That, wherever it is practicable, the kindergarden occupation be followed by instructions in industries approved by an industrial inspector as suitable to the locality, and that sufficient grants be made by the Department to provide the materials and appliances for such instruction.

8. That such instruction should not be by rule of thumb, but should explain the reason for every action; and that where, as in lace-working, woodcarving, &c., a knowledge of form and beauty is requisite, it is desirable that instruction in art should be given in the same school.

9. That the National Board's list of books should be thoroughly and promptly revised, or free trade in school books established in National Board schools.

10. That a complete series of industrial primers be prepared.

11. That the grants in aid of the purchase of teaching appliances, which are at present limited to £5 for each school, should be increased.

12. That salaries should be granted to evening school teachers.

13. That the results fees for instruction at evening classes should be much larger, and that in addition to the ordinary literary instruction subjects of a more practical character should be taught.

14. That, owing to the different circumstances of the two countries, the provisions contained in the Technical Instruction Bill introduced this session, excluding all children who have not passed the 6th Standard from the benefits of the Act, should not apply to Ireland.

15. That National school teachers should be given greater facilities to qualify to earn results fees in drawing, science, and industrial instruction. That district model schools be used as training schools for this purpose.

16. That managers of schools be empowered to engage travelling teachers to teach the elements of applied science and drawing, as well as approved industries, in schools where there is no resident instructor able to teach. That the National school teachers should be encouraged to learn from these instructors, so as to be able in time to take their place.

17. That three more Directresses of Female Industries should be appointed by the National Board.

People may object, no doubt. It is very well to say, "Give us a system of technical instruction;" but in connection with Ireland this is asking a good deal from the British tax-

payer, because, as the Chief Secretary pointed out last July, there has been spent on industrial schools in Ireland 2½ times as much as in England, having regard to the population. In ten years, from 1877 to 1887, the expenditure from imperial sources on industrial schools was no less than £800,000; besides this, the system of agricultural education is far in advance of anything of the kind in England. It must not be forgotten, however, that, as an Irish M.P. observed, in order to obtain the advantages of these industrial schools, excellent and admirable in every way as they are, a child must be either a vagrant or a criminal. My apprehension, however, does not arise from any doubt as to the British taxpayer declining to make the experiment suggested, nor would I be deterred by any difficulty incident to the re-casting of our eduational system. I am myself a believer in practical and technical education. I have nothing but approval, so far as my private judgment goes, for the general propositions set out in the memorial to the Chief Secretary, and for the very lucid exposition which they received at the hands of Mr. Arnold Graves. But my difficulty is this—When the Chief Secretary, in answer to the deputation, said that he understood "it would be agreed to see the industry *started* by independent enterprise, and merely that the Government should come in with its inspection and assistance, and that he might take it that this was the general opinion of the members of the deputation," the members signified their assent. Mr. Balfour proceeded to observe "that he understood Mrs. Lalor to say that she was of opinion that it was not sufficient to have the cottage industries, but they must have some kind of organisation to work them;" and he instanced a cottage industry in the north of Ireland where the organisation was provided by the manufacturers and those who managed the trade. Mr. Balfour proceeded:—"I do not believe it possible that cottage industry can succeed unless there are some philanthropists and capitalists prepared to provide that *directing* and *organising* fund, without which the poor people would manufacture in vain in their cottages;" and he further significantly adds:—"If the Government were to take up the cottage industry in that province they would take upon themselves a very serious responsibility." I am afraid—I may be wrong—that in the languishing condition of our industries outside Ulster, if we want to give them a chance of revival, the Government must infuse new blood into them by the assumption of some such responsibility. It must, I fear, in the absence of the sustained support of private philanthropists and capitalists, be prepared to assist for a time at least, by way of loan or otherwise, that "*directing* and *organising* fund" which the manufacturers provided in the north of Ireland. I think if we had some assurance to this effect, together with a favourable reception of the propositions set forth in the memorial I have read to you, that everything would be conceded which it would be possible to ask any Government to yield, and the result for failure or success would mainly rest with the people themselves.

You may ask me, "What is your idea of the prospect?" supposing you obtain this practical assistance and encouragement. Well, as I have already said, I look for no metamorphosis in the condition of the country; but I confess I do not see why Ireland, with a rural population, possessing, as it does, decidedly artistic tastes, should not absorb more of the profits arising out of such luxuries as lace embroidery. Remember, a million pounds worth of foreign lace comes into England every year. There are, moreover, numerous industries in which machine competition is very insignificant—wood-carving, box-making, envelope-making, toy-making, and all the many industries which, I am informed, give employment to one-sixth of the people of Germany; and I quite agree with Mr. Graves, when he says that there is no patent reason why they should not succeed amongst us as well as they have done in Austria, Bavaria, Tyrol, the Black Forest, or Thuringia. Why, for instance, should the Dublin buyer go to Germany for a box of wooden toy bricks such as I saw in a Dublin window the other day?

In addition to these trades and industries, at which I have been able little more than to glance, look what a scope for improvement there is in those arising directly out of the management of a farm. Books might—or I should rather say have—been written on the subject of the cheese, butter, cream, eggs, and poultry questions; cheese industry practically non-existent; butter, well £14,000,000 is paid annually to foreign countries for this commodity; and with regard to eggs, we are now paying in England £3,000,000 annually for our foreign supply, whereas 30 years ago we only paid £250,000. I suppose the pattern of an Irish egg is as good as that of a French one, and the market in England is perfectly open. There is also the sadly neglected

culture of vegetables and fruit, and it was only the other day that I read the report of some eloquent and magniloquent orator who spoke of the "illimitable future of jam."

But after all, fostered and encouraged as our trades and industries may be, we shall have to face competition, abroad and at home. In many of our cottage industries, especially, we have, in addition, to face the competition of machinery, and it here becomes very much a question whether the people will choose to win small wages rather than none. The foreigner has little hesitation in adopting the former alternative. I am sorry to say there is not the same alacrity always exhibited at home. A lady from the south of Ireland informs me that she knows of a case where a contract for knitting socks for a regiment was refused, because the people would not work for threepence per pair. I do not know where the contractor went, but I strongly suspect he crossed the border into Ulster, where I have reason to know his offer would have been accepted.

The analogies drawn between Ireland and Continental countries with respect to this industrial question, though useful of course as illustrating what might be done, are to some extent misleading when applied to the actual practical conditions of life in the respective countries. The French tenant of a small holding, for instance, or the peasant proprietor, works like a slave. His women and his children work; they know that they must if they are to keep a roof over their heads. Therefore, he has been accustomed to work desperately, and to do so has become a second nature with him. I am afraid the Irish peasant, especially in the south, has yet to acquire this nature; but this power of inertia must be overcome, before we can expect to see him established on that competing commercial basis without which his permanent condition can be raised by no amount of artificial and philanthropic bolstering. There is, of course, a dark side to every picture, but there is often a silver lining to the darkest cloud, and I think with respect to the future of Irish industries, we may fairly draw encouragement from the fact that the numerous body of energetic, philanthropic, and talented men and women who are taking up the question are doing so in a thoroughly earnest and thoroughly practical manner, and more than this, that there is at the present time an infinitely more wide and generous sympathy on the part of the great English people with the wants and possibilities of their Irish fellow-countrymen than has existed during any period of our history.

Ladies and gentlemen, I am fully conscious that in these remarks, which I am afraid you may think have been extended to a somewhat inordinate length, I have only been able to touch upon some of the aspects of this very large question, and you must excuse me if I have dwelt in what may appear a disproportionate degree upon the fishery question of the west coast, and the industries of Ulster in general. But I have been thrown in the way of giving the former subject much practical attention, and so large a portion of my life is spent among the people of our great and prosperous northern province, that it is but natural that I should be more fully acquainted with their condition and occupations than with those of other districts. I daresay I have not said or suggested much that has not been noticed and mentioned before. My object, however, has not been originality, and it will be fully accomplished if I have contributed in any degree to accentuate a few practical considerations in the minds of that very large section of the public who are interested in the present and future well-being of Ireland. I have said a very large section, but I think I might say that the whole of Great Britain has this great object in view to-day.

Whether you and I may live to see our aspirations fully satisfied; whether we shall indeed, in our own time, see that "Hibernia Pacata," the dream of so many successive generations, realised, I do not pretend to say. But, at least, we know that the days of an unenlightened and repressive policy are past, and that the miserable trade jealousies and antagonisms which have played so sinister a part in the history of both countries, are gone for ever with all the rest of

"Those old unhappy far-off things
In battles long ago."

And surely it ought to be true that the new platform of mutual sympathy and encouragement should be broad enough to hold all sorts and conditions of men, irrespective of politics, or race, or creed.

Sir Douglas Galton, K.C.B., moved a vote of thanks to the Duke of Abercorn for the very interesting, able, and statesmanlike address he had just delivered. He (Sir Douglas) congratulated the members of the Society on having secured a Chairman of Council whose views were so throughly in accord

with all the interests and principles which had guided the Society. The Society was formed for the encouragement and promotion of the industries and arts of this country nearly 150 years ago, and there was at the present time no part of the United Kingdom where it was more necessary that industries should be encouraged than Ireland. They might look with dismay and grief at the picture presented in the daily press on the condition of that country, but from this address it would be seen that there was a silver lining to the cloud, and that better things might yet be looked for.

The ATTORNEY-GENERAL, M.P., said he esteemed it a great privilege to be allowed to say a few words in seconding this motion. Sir Douglas Galton had referred to the original constitution and objects of the Society; and, remembering that one of those objects was the diffusion of the useful arts, all would agree that it was exceedingly wise that the Chairman of the Council should have endeavoured to enlarge the field of interest, by pointing out that there was in the sister island subject-matter well worthy of consideration, and useful development in the cultivation of the domestic arts and industries. He could not but feel that they owed an especial debt of gratitude to his Grace on this occasion, because he had not contented himself with merely recording statistics, or referring to data which might be gathered from trade returns, but had given the result of his own experience and thought, gathered by living amongst the people of whom he had spoken. He hoped that one result of this admirable address would be to lead the members to think how some of the practical ideas contained in it might be carried into effect; for it was to his mind certain that nothing was more likely to conduce to the peace and good order of the disturbed country than first to educate the people, and secondly, to encourage them to acquire habits of industry, activity, energy, and perseverance. By restoring credit, and making it more widely known that there were means of employment likely to be afforded to the people, the most lasting benefits would be conferred on every section of the population.

The vote of thanks having been carried unanimously,

The DUKE of ABERCORN, in reply, said he esteemed it a high honour to occupy the position of Chairman of the Council, and it had also been a great pleasure to him to address the Society on the general condition of the industries of Ireland. They were all aware that too little of the real state of Ireland was known by the English people, and that was a want which ought to be supplied. If Ireland were better known as it really existed, it would be more satisfactory for both nations. Sir Douglas Galton said he was glad to hear there was still hope for Ireland, and he could assure him there was every hope for it. There was the greatest hope for its future prosperity, but in connection with that he trusted that the people themselves would be fully alive to the advantage they would derive from promoting the interests of all classes in the country. Probably he might have been misunderstood with regard to the fisheries, and he might therefore say that he had not the slightest wish to deprecate the construction of small railways generally towards the coast, but he thought it would be unfortunate if too many were made without previously ascertaining in what direction they could best be made. The first thing should be to discover where the fish abounded, and then to find the nearest large harbour where it could be taken. Three or four large harbours made along the coast, and connected with the general railway system, would be more useful than a number of small ones, and such a plan would be less costly, and more likely to be profitable.

The Chairman then proceeded to present the medals awarded by the Society to the following gentlemen:—

To PROF. SILVANUS, P. THOMPSON, for his paper on "The Mercurial Air-pump."

To WALTER EMDEN, for his paper on "Theatres and Fireproof Construction."

To SIR PHILIP MAGNUS, for his paper on "Commercial Education."

To SWIRE SMITH, for his paper on "The Technical Education Bill."

To SIR HOWARD GRUBB, F.R.S., for his paper on "Telescopes for Stellar Photography."

To R. E. B. CROMPTON, for his paper on "Electric Lighting from Central Stations."

To HENRY COPPINGER BEETON, Agent-General for British Columbia, for his paper on "British Columbia."

To JAMES RANKIN, M.P., for his paper on "Emigration."

To MR. JUSTICE CUNNINGHAM, for his paper on "The Public Health in India."

To SIR WILLIAM W. HUNTER, K.C.S.I., C.I.E., LL.D., for his paper on "The Religions of India."

To J. STARKIE GARDNER, for his paper on "The Monumental Uses of Bronze."

To CECIL SMITH, for his paper on "Persian Textiles."

Miscellaneous.

BOTANIC GARDENS, NILGIRIS.

The following notes on some of the more interesting plants which have been introduced or grown in the Gardens during the year 1887-88 are taken from the report of the Government Botanist, Madras, which has been received from the India-office:—

1. *Phœnix dactylifera Date.*—The seed of this

palm, which was sent through Mr. Duthie, the superintendent of the Saharanpur Gardens, was completely destroyed by weevils before it reached its destination. As it has already been stated in my report, there can be little doubt but that the date would grow well in many parts of Southern India.

2. *Teff. Eragrostis Abyssinica.*—This grass seeded freely at Coonoor, and it is proposed to distribute the greater part of it to planters in the Wynaad.

3. (*Vitis Ampelocissus*) *Martini, or the Cochin-China Tuberous-rooted Vine.*—This vine is fruiting freely this year, and as the plant grows older, it seems likely that it will continue to yield an increasingly heavy crop every succeeding year.

4. *Medicinal Rhubarb.*—Plants have been put down in the garden at the jail at Coimbatore, and others will be planted out shortly in the new garden at Gúdalúr.

5. *Ipecacuanha.*—There are in stock altogether about 4,000 plants, 500 of which were planted out last year at Nilambúr. Out of these 500, three only have died, while the rest are vigorous growing plants, although they have been topped and the leaves stripped off them no less than three times during the last nine months. In accordance with the instructions issued in G.O., No. 2524, of 27th April, 1888, Revenue, about 2,000 well-rooted plants will be distributed, free of cost, to planters during the present season; the remainder will be removed for increasing still further the stock in hand. A set of instructions for the cultivation and propagation of the plant was printed and circulated last August. The reports on the growth of some few specimens which were put out in the Wynaad last year are most encouraging.

6. *Naregamia Alata.*—Mr. T. J. Ferguson, of Calicut, kindly procured twenty-six pounds of the air-dried stem and root of this plant, and sent it for experimentation. This was handed over to Surgeon-General Bidie, who has reported upon it as follows:—"It will be seen that, on the whole, the results of the trials of this indigenous remedy have been satisfactory, and such as to encourage its further use." From this report it will be seen that it is probable that in mild cases of dysentery the *Naregamia* may supplement the *Ipecacuanha.* Specimens of the *Naregamia* have been planted at Nilambúr, with the view of testing its rate of growth, in case further experiments should prove it to be a plant of high therapeutic value.

7. *Jalap.*—Between 5,000 and 6,000 tubers, of all sizes, have been put down in the Medicinal Garden at Dodabetta, besides several thousands of cuttings, but it is not expected that any appreciable crop will be harvested before the winter of 1889 or 1890.

8. *Rubber-yielding Trees.*—As a full report has so recently been made on these trees, it is only necessary to say that, while they grow vigorously, all attempts to extract the rubber, in anything like paying quantities, have up to the present moment completely failed. The *Cearas*, *Castilloas*, and *Heveas* all flower and fruit freely. The roots of the *Ceara* swell out into large tuberous nodules, which contain an abundance of starch, similar to that of *tapioca*, but unlike the tapioca, the roots contain no poisouous juice, and are palatable when either roasted or boiled.

9. *Quillaja Saponaria.*—This tree flowered and fruited in the Government Gardens, Ootacamund, for the first time this spring.

10. *Barilla.*—Several species, supposed to yield Barilla, have been experimented upon, especially the African *Osteospermum Moniliferum*, but none of them seem likely to be able to compete with the soda of commerce, the price of which is only £2 10s. per ton.

11. *Seakale.*—The plants which were raised from seed last year have grown so rapidly that by next spring they will be large enough to furnish a considerable cutting.

12. *Michelia Nilagirica.*—A quantity of bark was sent into the market in London under this name, but as it had evidently no chemical relationship with the *Michelia*, leaves of the trees, from which it was said to have been taken, were forwarded to me for identification, and which, upon examination, were found to be those of the *Gordonia obtusa* and of *Cinnamomum Wightii.*

The report also contains an account of a proposed new method for utilising cocoanut refuse. The Government Botanist writes:—Mr. J. W. B. Money, of Deva Shola, drew my attention last summer to an article entitled, "Batiment de combat et la guerre sur mer," in the *Revue de Deux Mondes*, dated the 1st of August, 1886, by a M. L. P. de la Barriere, in which he described, at length, how the refuse of the cocoanut, after the process of retting, might be used for backing the iron plates of ships of war. His mode of proceeding was simple enough, and is as follows:—He took a quantity of the powdered refuse before it was quite dry, and subjected it to pressure, when the natural viscidity of the macerated cellular substance of the cocoanut caused the mass to cohere, and the whole to form a plate which in general appearance was like a mill board, only much more brittle; owing to the hygroscopicity of this substance, if a hole is made through it, the parts adjacent to the puncture absorb water, swell up, and immediately close the orifice. When on the West Coast, last August, I brought away a sack of this refuse, and made a plate, eighteen inches square, by about $\frac{3}{4}$ of an inch in thickness, and placed it between two boards, and then fastened it to one side of a box, which contained a head of one foot of water. A bullet one-half inch in diameter was fired through it, but not a drop oozed out. This experiment was repeated three times with the same result; next a $\frac{3}{4}$-inch bullet was fired through the plate, when a few drops only made their way through; lastly a bullet near an inch in diameter was fired through the plate, when a large jet of water shot through, but in the course of a few

seconds the stream decreased in volume, and in less than a minute had ceased to flow altogether. Whether or no this material could be advantageously used for the purpose which Monsieur de la Barriere has suggested, or for any other purpose, it is a matter worth considering, for, as Monsieur de la Barriere truly says in his article, millions of tons float away annually down our rivers in India. All the above experiments were carried out under the superintendence of Mr. Money on his estate at Deva Shola.

THE TRADE IN RABBIT SKINS.

When the Acclimatisation Societies of Australasia introduced the rabbit some years ago they thought they were accomplishing a good work, and little anticipated what a serious injury these rabbits would effect in less than ten years, and that their extermination would be a costly and impossible work. Rabbits have so increased now in Australia and New Zealand that the colonists are at their wits' end how to repair the evil. The extent of the injury done to the pasturage required for sheep may be inferred, in some measure, from the enormous number of rabbit skins exported, which, however, prove a blessing to the cheap furriers of Europe and America. A local industry has also sprung up in the colonies in making soft felt hats from their fur. Coney wool was encouraged and valued in England a hundred and fifty years ago, and is now worth 7s. a lb. The damage done to the crops in the Australian colonies by the little animals that furnish the skins for export has become of such magnitude as to furnish the subject of Parliamentary legislation there.

From the single colony of New Zealand there has been exported about 70,000,000 skins, valued at nearly £750,000. But the property destroyed by these rodents is estimated by millions; and this industry of rabbit skins is one which the people there do not wish to see prosper. In Victoria the colony is asserted to have sustained a loss of about £3,000,000. The cheap linings of coats and ladies' cloaks, and many of the dyed articles of fur, are due to rabbit skins, home and foreign. In the last 10 years 29,000,000 rabbit skins have been exported from Victoria. In addition to the exports from the Colonies many have been used locally by hat manufacturers and others, and large numbers have doubtless been destroyed or allowed to decay. The extensive supply from Australasia has flooded the English market, and the trade has on hand a supply sufficient to last for a year or two.

The English rabbit breeders also found it to their advantage to kill rabbits mainly for their skins, and the supply of home skins is said to reach 30,000,000 annually. Belgium, which supplies us with the tame-bred rabbits so largely appreciated and imported for food, sends away over 6,000,000 rabbit skins, but then these skins are much larger, of a finer colour, and better fitted for furs than those of the wild rabbit.

In some of the Australian colonies attempts were made to preserve their flesh in tins for food. One company in South Australia employed forty or fifty trappers, and thus prepared 6,000 or 7,000 rabbits a day. But this utilising process has been dropped since the wholesale poisoning and other methods of extermination have been resorted to, the public becoming shy of eating the rabbits as food.

Obituary.

John Collins, F.C.S., F.G.S.—Mr. Collins, analytical chemist and consulting chemical engineer, of Bolton, Lancashire, and a member of the Society of Arts, died on the 28th August last. Mr. Collins was born in 1832 at Darton, in Yorkshire. He was educated at Chester College, and on his leaving there he was appointed Head Master of the Manchester Collegiate School. He continued his scientific studies, and subsequently became chemist to the Bolton Iron and Steel Company. He devoted special attention to the question of sanitation, and originated a process for the treatment of town sewage called the "M and C Process," used at Bolton and elsewhere.

MEETINGS FOR THE ENSUING WEEK.

Monday, Nov. 26...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures). Captain Abney, "Light and Colour." (Lecture I.).
Surveyors, 12, Great George-street, S.W., 8 p.m.
Geographical, University of London, Burlington-gardens, W., 8½ p.m. Mr. Joseph Thomson, "Journey to the Atlas Mountains."

Tuesday, Nov. 27...Civil Engineers, 25, Great George-street, S.W., 8 p.m. Mr. J. Evelyn Williams, "The Witham New Outfall Channel and Improvement Works."
Anthropological, 3, Hanover-square, W., 8½ p.m. 1. "A Gold Breastplate from an Ancient Peruvian Grave." Exhibited by the President. 2. Rev. Benjamin Danks, "Marriage Customs of the New Britain Group." 3. Mr. Osbert H. Howarth, "The Survival of Corporal Penance."

Wednesday, Nov. 28...SOCIETY OF ARTS, John-street, Adelphi, 8 p.m. Colonel Gouraud, "The Phonograph."
Microscopical, King's College, W.C., 8 p.m. Conversazione.

Thursday, Nov. 29...Antiquaries, Burlington-house, W., 8½ p.m.

Friday, Nov. 30...Civil Engineers, 25, Great George-street, S.W., 7½ p.m. (Students' Meeting.) 1. Mr. Edwd. T. Hildred, "The Covered Service-Reservoir of the Southampton Corporation." 2. Mr. Herbert Ashley, "The New High-Level Storage-Reservoir for the Grand Junction Waterworks Company at Hanger-hill, Ealing."

Journal of the Society of Arts.

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FRIDAY, NOVEMBER 30, 1888.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

SWINEY PRIZE.

The Council have to give notice that the next award of the Swiney prize will be in January next. Dr. Swiney died in 1844, and in his will he left the sum of £5,000 Consols to the Society of Arts, for the purpose of presenting a prize, every fifth anniversary of the testator's death, to the author of the best published work on Jurisprudence. The prize is a cup value £100, and money to the same amount; the award is made jointly by the Society of Arts and the College of Physicians. The cup now given is made after a design specially prepared in 1849 for the first award, by D. Maclise, R.A. Any person desiring to submit a work in competition, or to recommend any work for the consideration of the judges, should do so by letter addressed to the Secretary of the Society.

The following is a list of recipients :—

1849. J. A. Paris, M.D., and J. Fonblanque, for their work, "Medical Jurisprudence."

1854. Leone Levi, for his work on "The Commercial Law of the World."

1859. Dr. Alfred Swayne Taylor, F.R.S., for his work on "Medical Jurisprudence."

1864. Henry Summer Maine (afterwards K.C.B.), D.C.L., member of the Legislative Council of India, for his work on "Ancient Law."

1869. William Augustus Guy, M.D., for his "Principles of Forensic Medicine."

1874. The Right Hon. Sir Robert Joseph Phillimore, D.C.L., for his "Commentaries on International Law."

1879. Dr. Norman Chevers, for his "Manual of Medical Jurisprudence for India."

1884. Sheldon Amos, M.A., for his work "A Systematic View of the Science of Jurisprudence."

Proceedings of the Society.

SECOND ORDINARY MEETING.

Wednesday, November 28th, 1888; Sir Frederick Bramwell, D.C.L., F.R.S., Deputy Chairman of the Council, in the chair.

The following candidates were proposed for election as members of the Society :—

Carter, Joseph Robert, 14, King's Arms-yard, E.C., and 2, Steele's-road, N.W.

Day, Richard Evan, 48, Belsize-square, Hampstead, N.W.

Dowis, Philip H., 171, Queen Victoria-street, E.C., and 106, Salcott-road, S.E.

Jones, Henry Arthur, Townshend-house, North-gate, Regent's-park, N.W.

AND AS AN HONORARY CORRESPONDING MEMBER.

Berger, Georges, 12 Rue Légendre, Paris.

The Chairman, in introducing Colonel Gouraud, said the Society collectively was not interested in pure science, though its individual members were, but the Society itself was interested when scientific matters were made practical. On this occasion the paper about to be read would embrace both pure science and its practical application to useful purposes, and the Society was to be congratulated on having such an interesting subject brought before it as the new Phonograph.

An Address was delivered on—

THE PHONOGRAPH.*

By Colonel Gouraud.

I must begin what I have to say by making a confession in order that you may not be disappointed too much in what will follow. I am not a lecturer. I am not a public speaker in any sense. I have only one excuse for speaking here to-night, that is one which I hope will commend itself to you, from the simple fact that I am by accident the possessor of something, and some information about something, which at this moment is interesting a very wide *clientèle*, I might almost say world-wide, I having received from Mr. Edison the first perfected phonograph which left his hands; and at the time at which it left his hands he had not another one remaining to himself. He was without another more than three weeks. That phonograph I have, and I have had an experience which is peculiar—unique—because my experi-

* This is a report of Colonel Gouraud's address printed from the shorthand writer's notes.

ence with it has been of all kinds, which even Mr. Edison himself cannot boast, because I have used it practically, while he has but used it to see how he could improve it.

Now, when invited to address you here to-night, I was told that the Society of Arts would expect to be told a great deal about science. Sir Frederick has told you that you are not necessarily to be inflicted with all that I know, which is not very much, about the science which underlies this subject. I confess I I intended to give you a fuller description of the underlying principles until this afternoon, at a very late hour, when there was placed in my hands the address on the original phonograph, given at this place, ten years ago, by a gentleman far more competent to deal with the subject than I am, viz., Mr. Preece, a distinguished member of the Society. In the course of his remarks I find he went very thoroughly into the subject of the science of acoustics. I therefore propose to leave all that out, to do which I have had to discard what may be considered a quarter, at least, of my address, and to that extent at least you are to be congratulated. I had prepared illustrations of the effect produced by sound-waves, and had intended to tell you something which you know quite as well, or better perhaps, than I do. I shall leave that out, but in doing so, before I come to the subject of the phonograph—to which I shall confine myself in order to be as brief as possible—I will remind those who may have forgotten it, and inform those who perhaps never knew it, that there is nothing in sound or the science of acoustics so extraordinary as the very thing I am now doing—speaking. There is nothing so complex or so extraordinary as that most extraordinary gift of Almighty God—speech. There are two or three things which I will point out in that connection, just to bring more forcibly before you what sound is. When I tell you that in musical sounds alone there is a range of from 40 to nearly 5,000 vibrations in a second—in the case of those sounds occurring in the presence of the phonograph they go into the phonograph—they make their record there, and there they stay until you bring them out again. But that is not all. In the range of sound-waves beyond the limit of that which is described as music, the vibrations to the second are no less than 41,000. That gives you some conception of the kind of work that an instrument must do, in order to respond to such a variety of conditions as is presented in the whole range of sound. You may say, will the phonograph take all that in and give it back? All I can say is, that we have as yet failed to produce any form of sound whatever in the presence of the phonograph which it has not faithfully reproduced. It speaks all languages with faultless or faulty pronunciation, as the case may be, plays all musical instruments, from the solo to the complete orchestra, whistles, sings, laughs, and cries at your pleasure. Now when you think of it, that is doing something more really than a human being can do, because you may hear what I say, and you may think you can repeat it. Perhaps you can, with more or less likeness to what was said, but it is only more or less—but never is exactly the same. No one can imitate the measure or volume and the quality of a given sound. The phonograph does that, and in doing that does up to a certain point, it seems to me, all that a human being can do, and beyond that point is something more than human, because in giving it back exactly the phonograph does more than the human being can do. I make one broad distinction between the powers of the phonograph and human powers, viz., mechanically it is superior, but it lacks imagination. It will only hear what you say to it. If you leave out your r's at the end of your words, or your s's or h's, it will not give them back to you. I am now going to take for granted that you know the main principle the phonograph. I will throw upon the screen a view of the original form of the instrument. The original phonograph consisted only of a metal drum with a spiral thread cut round it, as you see in the broad black lines there represented. This view represents the second form, in which, in order to insure greater regularity of motion, more especially with respect to the reproduction and repeating process, driving weights were employed. The drum was also supported by a horizontal shaft, which stood upon bearers (not shown very well here), but which had cut upon them a screw, or spiral thread, exactly to the same pitch as that cut upon the shaft carrying the cylinder. The effect, therefore, of turning this handle is to revolve the shaft and cylinder, and cause it to pass along from one end to the other; so that if you began with the needle on the diaphragm (which I will explain presently) at this end, and talked till the needle reached to the other end, the record would finish at the left hand of the drum. The cylinder carried a sheet of very thin tin-foil securely fixed upon it. A fixed arm carried

a small diaphragm of mica. In the centre of this diaphragm was fixed a piece of metal resembling a needle, about as thick as an ordinary sewing needle. When you were ready to speak you adjusted this arm so that the point of the style or recording needle touched lightly on the surface of the tin-foil, and you were then ready to make a record. You spoke, and set in motion sound-waves which impinged upon the diaphragm, on the centre of which it struck. Opposite this mouthpiece, above the diaphragm, which was about 1 in. or $1\frac{1}{2}$ in. in diameter, the portion exposed being perhaps only an inch, and at the centre of the cylinder, was the box of the needle. That diaphragm vibrated, and the vibrations communicated themselves to the tin-foil in the form of little indentations, which looked very much like pin pricks and scratches upon its surface.

That was all you had to do to make the record. You will understand, of course, that when you were speaking you were turning this handle, or it was being turned by these weights, so that the tin-foil was passing under the needle, with the consequence that each vibration as you made it, or a set of vibrations, acted upon a fresh surface of tin-foil. That was the operation of making a record in the original phonograph, and that is also the operation of making a record in the present phonograph, but with very different results, as will be made apparent to you shortly. Then, when you had made your record, and wanted to repeat it, in the original phonograph you turned this back again until you got the point of the recording style over that part of the tin-foil at which it began its record, and then you had only to pass the surface of the tin-foil now indented in little ups and downs again under the needle, and the effect of those irregularities in the surface of the tin-foil was such as to agitate the needle, and consequently to agitate the diaphragm hundreds and even thousands of times a second, as was necessary to respond to those irregularities which were the substantial equivalents of the sound-waves set up in the first instance by the speaker. That was the whole operation of the instrument both in receiving and rendering the words or other sounds communicated to it.

I will now make one reference to this diagram, which shows the vertical section of that machine which I have been explaining to you. You are now supposed to be looking at the end of it. This is the end of the cylinder—that black line represents the tin-foil, and there is the needle attached to this point reacting in various ways. This diagram gives a very good idea of it. In this case the base of the needle was resting upon a cushion of india-rubber, and the other face of that cushion touched the diaphragm, which was this blue line. This is the mouthpiece—that is the mouthpiece, and it gives you a very fair idea of what the original phonograph was. I will only say one word more about the original phonograph. When Edison made his discovery he was not actually looking for the result which he found. He had been long experimenting upon an apparatus with a totally different object in view. He certainly had, and I have had it from himself more than once, over a period of many years, in common with many other philosophers both of his own time and of preceding generations, dreamt of the power of reproducing human speech, This has been the dream of philosophers, from all time, as well as the theme of poets. When Byron received his mother's portrait, he wrote to her, "Only the voice is wanting." And I feel certain that the poet realised what would have been the additional value of that life-like likeness of his mother if he had been able at the same time to hear the familiar tones of her voice. But Edison thought of this thing suddenly, to use his own words to me, shortly after his great discovery—"It suddenly occurred to me if that thing would do what I was trying to make it do—that if I spoke to it, it ought to speak back." He hurriedly made a few changes in the apparatus upon which he was working, spoke into it, and what he first said into it was, "Mary had a little lamb; its fleece was white as snow." He looked about him, and saw standing near him a German workman named Fritz. He called Fritz to him, told him to put his ear down there, and that is all he said to Fritz. Fritz put his ear down. Edison started the machine in motion, and he said to me, "I watched that Dutchman's face; it was a curious thing to observe the changes of expression that came over him. Finally he straightened himself up, raised his hands in the air, and said, 'Mein Gott, she speaks." The phonograph first spoke in the laboratory of a man who was the night before unknown, except to a very small circle. I had the good fortune of knowing him already ten years, he having been in a certain sense a discovery of mine, now twenty years ago, and when I first met him I felt

that I was in the presence of a man the like of whom I never knew before, and whose equal I have yet to find. The next day almost, literally speaking, that man's name was known the world over. Every telegraph-wire flashed the fact under sea and across continents, and it was the theme of discussion, discourse, amazement, and delight in every language, I suppose, on the face of the globe, with—need I add—a plentiful mixture of incredulity. Shortly after Edison came to be well known also in connection with his work on the telephone, to which he contributed, as every one knows, that marvellous and indispensable portion of the instrument into which we speak—the carbon transmitter. It is his patent which is holding the monopoly possessed by the companies who own its rights all the world over, and, in saying that, I detract nothing from the value or the reputation of the inventor of that equally beautiful portion which is at the other end of the wire in the hands of the listener when he receives the message from a distance.

Then came the electric light, which took Edison's mind almost entirely off the phonograph for a time, though he never forgot it. I have seen myself whole volumes of notes, memoranda, and drawings for future experiments in connection with the phonograph, and these are thousands in number, of which hundreds are still untried, notwithstanding all that he has accomplished, as is shown by the instrument now upon this table. But a little while ago, within the year, there came whispers—"Edison has perfected the phonograph," and again the phonograph was the subject of conversation the wide world over, and the subject of newspaper articles and comments, perhaps unprecedented in number. Its arrival and appearance in public was awaited with great expectation. At length the first improved phonograph did come, as you all know, to England. I was very glad, for many reasons, that it did first come here, and, of course, glad that it came to me. Without being able to say why, it seemed to be fit that the first phonograph should come to the mother country.

I am going to show you presently, upon the screen, a faithful view of that phonograph. I will first introduce to you Edison as we know him in his leisure moments, which are rare. He has a face full of intellect, as you will see, a magnificent massive head, clear eyes, and regular features, a powerful physique, and a proportionate constitution. His very life is his work, for which he has a capacity as phenomenal as some of the products of that work with which you are now familiar. With his past experience, and facilities which are now illimitable, it seems to me that his best work is before him. His nature is genial, and he tells a good story, and enjoys one as well as as any man I ever met.

This is a view of the phonograph as we now know it—the so-called perfected phonograph; and in making use of that expression, I may say it must be taken only as a figure of speech. It has been so improved upon since the first phonograph came here, and will be so much further improved, or rather has been already, than even the instrument which I last received, that I do not know what a perfected phonograph will ultimately really be. Here you have the same fundamental principles involved, and I shall not, therefore, go into them again at all. In this case you have an iron frame supporting a shaft, as before, but this time working on centres—delicate points at each end, and the same combination of screws for working it backward and forward, but with greater facility. You have there the phonogram, as we call it. I do not know exactly what it is made of. It was a little while ago made of wax, or compounds of wax in various proportions, treated in various ways, which we call phonogram blanks until we get something upon them, when we call them phonograms. This view shows the phonograph with the phonogram blank upon it, locked into position by the closing of this arm, which closes on a hinge. This frame carrying the diaphragm rests upon a box, which at this end contains an electric motor. The motor is actuated by a small battery, which at a inappreciable cost will run the machine, in the aggregate, for about fifteen hours. This motor is the result of a large amount of experiment, the difficulty being to combine high speed with regularity and silence, and a small battery with economy of current and cost. A governor regulates the speed at which the motor turns, and is itself controlled by a screw, thus communicating to the cylinder carrying the phonograph any desired speed, to the nicest point of precision. Absolute precision in this respect is an essential of the highest importance, without which the voice of the speaker could not be recognised, and music would become discord.

In making any important record for preservation or transmission abroad, note is made

upon the phonogram itself of the speed at which the record was made, so that when repetition is desired you have but to set the governor at the indicated speed to insure faithful reproduction as to tone and quality. You put the phonogram on the cylinder, and you start the operation of the battery by closing the circuit. By removing this little plug from one hole to another, and by turning this screw to the right or left, you regulate the movement of the cylinder to the precision of one revolution a minute. You have here an arm which carries what I have before described to you as the recording diaphragm. In the original phonograph there was only one diaphragm. The results were sometimes better when Edison made the record with one kind of diaphragm and the repetition with another kind of diaphragm, than if he made them both with the same diaphragm. In the present phonograph he uses two—one for recording, another for repeating. The recording diaphragm is of one material, and the repeating diaphragm is of another. They differ also as to thickness. So again do they differ with respect to the needles or styles. There are also important differences in respect to the recording and repeating tools. In short, there are so many niceties of arrangement on the part of the inventor, that I am ever forcibly reminded of the striking title of Sir Frederick Bramwell's brilliant address before the British Association on the "Next to Nothings" which, of course, are the all-essentials to perfection in anything, of which philosophy Edison's work affords a brilliant proof.

There is the same view of the phonograph, with this difference that the spectacle, as we call it—it is very much like a pair of glasses, as you will see—which carries the diaphragms is down in position, though the diaphragms are not in. I have taken this view in order the better to explain it in connection with the work it has to do; as you see it now, it is in the position for speaking. You are seeing through the frame, the consequence of which is you see, and I call your attention to this object which appears to be, and is in point of fact, attached to the arm, but which in effect is the turning tool whose function it is to plane off the surface of the phonograph. For the better understanding of this, I must tell you that, whenever the phonograph is being used, and you have talked the surface full—or, so to speak, covered your paper with writing—and the amanuensis has transcribed what you have said, provided you have no longer occasion to preserve that record, you do not have to throw away the whole phonogram, as was the case with the original phonograph; but you may plane off surface after surface, until the material is exhausted. In the beginning there was only one surface, but in the next improvement there were ten surfaces to one phonogram, which was a quarter of an inch thick; and in the phonograph which you will see here to-night the phonogram has a capacity of no less than thirty sutfaces, which I think may be safely called a rapid way of cheapening stationery. The importance of this is obvious. And while I am on that point, I may as well tell you that amongst the items of still further improvement which Edison has effected, he tells me in a recent letter that he has, in connection with the new material of which he now makes his phonograms, and which I am not at liberty to disclose here, a process which allows him to make 200 surfaces, so that you can form some conception of the practical effect of that in the introduction of the matter commercially. One more word upon this point, because it is of enormous importance that you should all understand and realise the extent to which the phonograph may be used. I use the phonograph for the purpose of answering all my letters every day, and if I had to have for every letter I dictated a separate phonogram, I should need to buy an extra house in which to keep my stationery; while, as a matter of fact, the phonograms take up very little room, and, of course, a 200-surface phonogram would take up proportionately less.

The next photograph shows the diaphragm in position, but not yet complete; that is to say, you have now to attach something if you want to speak to the cylinder, which is simply a tube pointing to the centre, so that the sound-waves go through the tube, and are conducted directly from the mouth of the speaker to the diaphragm which I described to you just now. When you wish to listen, you switch into position the repeating diaphragm by simply turning the spectacle upon the hinge by which it is attached. The instrument is so mechanically constructed that theoretically the needle of the repeating diaphragm falls exactly into the track made by the recording style. The spiral in this case is no less than 100 threads to the inch. It is scarcely visible to the naked eye, while the record which is at the bottom of the track is so fine as to be visible only by means of a magnifying glass. Not the least surprising

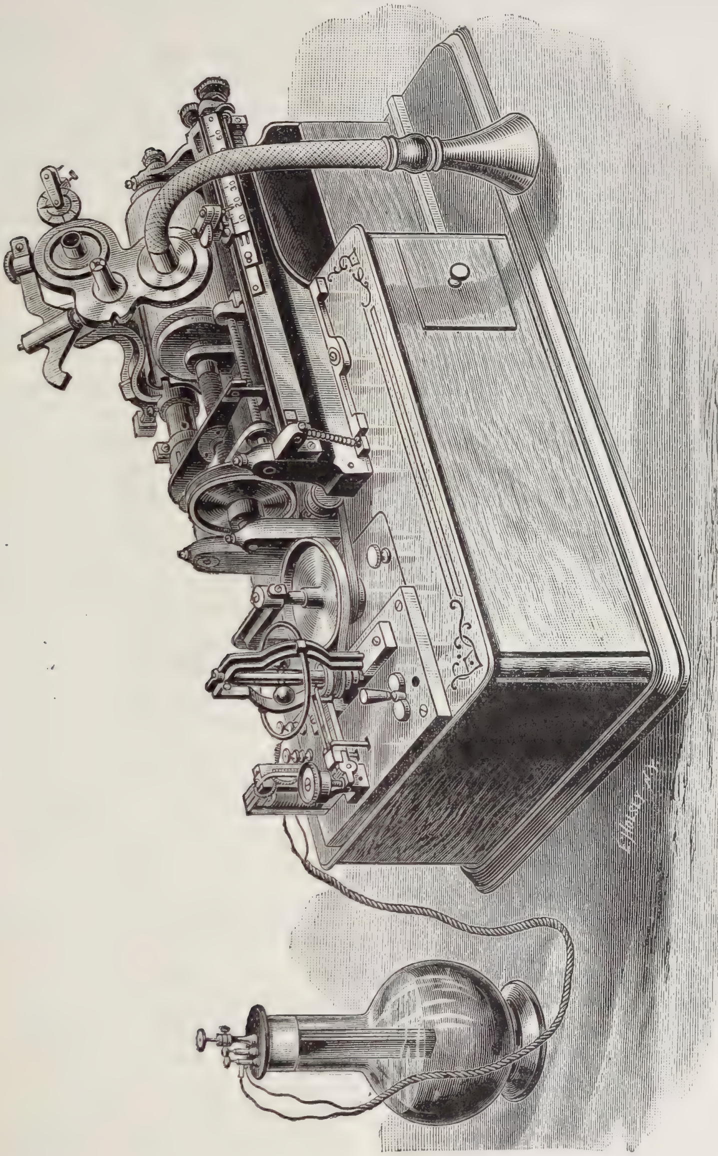
feature is that, notwithstanding the reproductions of these infinitesimal impressions are due to friction between a soft material, such as wax, in contact with a metal point, repetitions have been made to the number of 3,000, beyond which no count has yet been kept.

The next photograph is an end view, which illustrates an important point in the manipulation of the instrument, and which is fundamental in respect to its utility. There is a small screw shown there, and when you have turned it enough the needle is dropped down into contact with the surface of the phonogram ready for making the record. It tells you that it is ready by a little hissing sound, which is the result of the point of the recording style scraping the surface of the phonogram. This is of great importance, because when once you hear that you know that everything you say goes in. If you cough, if you hesitate, if you lose your temper and slam the door, it all goes in. But by an inverse operation, by turning the same screw back towards you, the hissing stops, and then you may clear your throat, or cough, or slam the door as much as you like.

The amanuensis has sat down to write what has been spoken. A certain number of words are delivered off by the phonograph to the ear of the writer. The number of words is controlled, not only to a word by the writer, but to a syllable of a word, or to a portion of a syllable if you wish. Although you never have any necessity to do that, it shows the precision with which you can work. I have a rapid writer who transcribes from the phonograph letters dictated at an ordinary speed without stopping the phonograph from the beginning to the end. By the operation of turning a screw you give off as many words as you can conveniently take down, or think you can write from memory. But if you have taken out too many words through the tube at which you are listening, and you are not quite sure about the last two or three words, it may be a date, or an unusual name, or word, then all the operator has to do is to turn the screw a little further, and the phonograph, or, rather, the diaphragm, goes back, drops the needle again into the crack, and repeats the word or sentence, as the case may be. You may not hit it exactly, but you hit it very nearly, and, with a little practice, you will hit it with almost absolute certainty. That feature, if you think for a moment, answers in anticipation a question which is always asked. You speak into the phonograph with great rapidity; how is anybody to write that out? True, you may speak rapidly or slowly, in a loud or a low voice. You may have the repetition at a lower rate of speed than that at which the record was made, or you may have it at a higher rate of speed; but if you vary the rate of speed in the repetition the least particle, one or two or three revolutions in a minute, which is very fine, you alter the pitch of the voice, and consequently you alter the quality or the timbre. Now the practical bearing of that illustration is this—and from its importance I wish to impress it on you all, that unless the phonograph reproduces the pitch and quality of the voice, you could not identify the speaker. Its importance with respect to music is simply incalculable. Music is music if you make the repetition at the same rate of speed, and it is not music if you do not. You may say a phonograph might have done without music; and so it might; and long have I laboured with Mr. Edison to give up the idea of music. He was always singing into it, or whistling into it; but the fact is, the man is passionately fond of music. Mr. Edison is deaf, so that he is denied the privilege of hearing good music. He has always said: "I am going to make the thing give me good music, as it would give me and others pleasure. Do you mean to say that what will give pleasure will not be more satisfactory to the world at large than that which is only useful without giving pleasure?" So he went on, and made the phonograph as perfect in the reproduction of music as of speech.

In the phonograph on the screen you will see that the little arm projecting from the shaft releases the screw, but the object of the little arm is to do away with the very objection which occurs to many of you when describing the movement of the hand, viz., what are you going to do with your hand when you need to lay down the pen, and so on? Mr. Edison anticipated all that, and he controls that shaft which performs all the important functions by the means of this little arm, to the end of which is fastened through the little hole, a string, or wire, at the end of which is attached an ordinary wooden pedal, such as one sees in a piano. When the amanuensis sits ready to work, the normal position is with the feet resting on the pedal. Everything is going now; the battery is working, the motor is turning, the phonogram is revolving upon the cylinder, passing under the point of the diaphragm; but the point of

the repeater in this case is not in contact—very nearly so, but not quite—with the surface of the phonogram. Here the transcriber sits, with pen and paper ready by his side. He raises his toe slightly, and hears "My dear sir." He drops his foot, and writes these words, and again raises his foot, when the phonograph says, "I have your letter of the 25th instant," and so on, when he drops his foot to write this, but perhaps forgets if it really was the "25th instant," and has this repeated. It is not necessary to lay down the pen or do anything



Edison's Improved Phonograph.

which is not done in writing at first hand; you merely raise the foot when you want the phonograph to speak, and drop it when you want it to be silent, which is when you are writing. Of course, it is not necessary that you should use an electric battery, but it is obviously desirable to use anything which will give you no more work to do than that which I have described, putting the plug into the hole, and letting the motor and governor do the work for you.

There are some theories abroad, which no

doubt, you will hear, that all this is very complicated — motor, governor, machinery, and all the rest of it—that no one will have anything to do with it when they can sit down in front of a thing which is a mere sewing machine with a treadle, and can be worked with the feet. That is a very plausible argument which has been advanced, and will probably be advanced again, but you will form your own opinion as to the merits of the argument. The only thing about the "intricate machinery" is that it is simplicity itself to the operator; it was intricate, no doubt, to the inventor, but that was his work and not yours. In use it is the essence of simplicity. However, Edison has made a machine, and I have a photograph of it, which will just meet that sort of peculiarity in the public mind which sometimes crops up in the early days of a thing when the public think they want something rather different from what they are offered. That Edison recognises this peculiarity is illustrated by a recent communication to me when he says, "I am going to make for the public what I think the public ought to have; but if the public want something else, they shall have it as they want it. If they find what they think they want is better than what I think they ought to have, I will give it them; but if they ultimately come to the conclusion that I know more about it than they do, they will adopt my views as to their requirements." This combined foot-power and electric-power machine is being made, and will be put on the market. If you think you want to exercise your legs and work your feet while writing, you will do it and enjoy it; whether you will write as well is another question. The foot-power may serve for ordinary dictation purposes, but not for music, and is a reserve force in the event of possible accident to battery.

The next diagram shows the repeating diaphragm in position, but with a speaking trumpet at its mouth. That you will see used here presently, when I shall try and make the phonograph say something which you will all hear, but which when you hear will be heard by you under the distorting influence, which must be clear to you as necessarily the result of talking or singing through a tin trumpet. It brings the sound out very loud, but is not flattering either to the phonograph or the original speaker.

All the world has heard something about the first phonogram, and this picture represents its reception at Little Menlo, Norwood. I sat down in front of the phonograph with some of my family about me, and in anxious suspense. I believed I should hear something, though it did not seem to me possible that my high expectations could be realised. I felt myself face to face with the most interesting event of my life. I said to Mr. Hamilton, who brought the instrument to me, "I am ready; go ahead." He put the plug in the hole, and the first thing I heard was a cough, perfectly distinct. It was Mr. Edison clearing his throat. I could almost recognise his voice, even in his "ahem." There was no mistake about it, when, after clearing his throat, I heard, "Friend Gouraud," and it went on to describe the fact that this was his first phonogram, that it was sent by the North German Lloyd steamer, and that he had sent material with which "to talk back to him," as he expressed it, and he concluded by an observation which was not very complimentary to me, as it rather reflected on my handwriting. It said, "What a God-send it will be to receive phonograms from you instead of your writing."

I sat down, not in ill-humour, as I appear to be in that photograph now before you, to send my phonogram to him instead of my writing. I put a phonogram blank on to the cylinder, turned the screw, began my answer, and since that time I have talked across the Atlantic with Mr. Edison with no further effort than that described. The mailing phonogram differs from the office phonogram in that it is thinner, having only two or three surfaces. If Mr. Edison happened to be out of phonogram blanks he could turn off my talk and talk his own on in its place, and then send the same cylinder back to me. The phonogram is put into a box, so made as to keep the surface of the phonogram from coming in contact with the inside of the box proper. I sent one to Mr. Edison for a penny, though I rather horrified the Postmaster-General when I told him so. It cost a penny to send instead of 2½d. as a letter would cost, and I am justified in this, as the postal regulations allow me to do so. I think the Postmaster-General said, or if he did not he ought to have said, that when phonograms came in, as they must come in, because all the world would use them, he would have to change the law. I said we did not propose to have anything to do with the Government in connection with phonograms if we could help it, and we proposed to assimilate the form of the mailing phonogram as much as possible to

the form of an ordinary letter. That seemed a startling proposition to make.

Mr. Edison had told me he could do it—because I said this will never do; it means Government in the end; do not let us have Government at the beginning or at the end—he recognised the situation perfectly, and simply wrote back, "I can do that, so that the mailing phonogram will take up scarcely more room than an ordinary letter," and I may say that he has since—within the last ten days—sent to me in this connection a further patent. The phonograph is now being more widely patented than any of Edison's previous inventions. While this will delay somewhat the supply of phonographs to an eager public, they will, when they are ready for distribution, answer all that is required of them. Phonographs are being made now by thousands, some 200 men being employed thereon night and day.

The next photograph which I throw upon the screen is a very interesting one, because it represents Mr. Edison in the act of realising that he has reached his goal. He is, through the medium of his phonograph, hearing the voice of his friend in Europe. He had, of course, talked to the phonograph many times, and I am here reminded that there is one word which he has uttered in the presence of the phonograph millions of times, and, curiously enough, it was a word which he first spoke into the original phonograph—a word which represents to the phonograph all the difficulties of language, it is his test word. He said, "When the phonograph can say 'fleece,' it will answer every requirement." Need I add that the phonograph now says "fleece." In passing from this photograph I may call attention to one thing which has been frequently remarked, and that is the Napoleonic countenance of Mr. Edison. Fortunately for humanity his genius takes a different turn. He is, however, a Napoleon in his methods; for example, when wanting fibres for filaments for the incandescent lamps, he did not write to A B or C to send him fibres, but he sent men all over the world to get them and bring them to him.

Now I will run through as quickly as possible a few of the everyday uses to which I put the phonograph and to which you will all put it in due time. I sit down in the morning or evening, or frequently at midnight, after receiving a large mail, which comes in at ten o'clock at night. When my letters come at night they are read to me, or if they come in the morning I read them myself, and as I read them I dispose of them. There is an enormous convenience, which any man who has a large mass of correspondence to deal with will realise, in being able to dispose of your correspondence at first sight. When you have read a letter you get rid of it. I talk long talks into the phonograph, long letters, and other material not letters, matter requiring more thought, something I have to do which is not exactly in the nature of a letter. I talk that into the phonograph and go away; the letters are written out in my absence, and sent away without my ever hearing the phonograph repeat them. I heard the phonograph tell me all the time that it heard me, and that is all I want to know. Once the phonograph hears me, then as my secretary says, it would be a crime for anyone to make a mistake in writing from the phonograph's dictation; it would be gross carelessness; nothing would excuse an error from phonographic dictation.

The next picture shows my secretary writing with a pen in perfect silence. One of the reasons for making the phonograph in the form requiring the use of a tube to convey the sound from the phonograph to the ear of the writer, is to prevent any one else hearing it. Thus half-a-dozen clerks in an office may use it without disturbing each other. It is meant to be a commercial everyday instrument.

The next photograph shows the same thing with the type-writer, that enables a manuscript to be written out in nice, clear type, in about half the time, more or less. There you see the string attached to the arm, and the lady's foot is on the pedal. It is very interesting to go in and see anyone writing like that, very quietly, something which was spoken the day before.

Here is another fancy sketch, though it is a very practical thing. It is a photograph of myself and a gentleman who did me the honour, on behalf of that very enterprising newspaper, the *Pall Mall Gazette*, to come to me in the early days of the arrival of the phonograph in England, and make this startling proposition to me, "Colonel Gouraud, I want to see if this thing is really what it is cracked up to be, and the only proof to me will be if I can interview you." I said I should be happy to give him any information, and we sat down, and he interviewed me. He asked me questions, and I answered them, both of us speaking into the phonograph, and

then we went our respective ways. When I returned home that night, the lady whose photograph you saw just now, had written down the whole of that interview, and I had not an alteration to make in it. It was sent to the *Pall Mall Gazette*, and printed exactly in the form in which she took it from the phonograph, with the result of four or five columns which were heralded to the world as the first interview through the phonograph. The next photograph shows a newspaper editor, surrounded with the newspapers. He is reading, and all he has to do is to say what he wishes to have written. He may be talking his leading article. For dictation, again, the phonograph is made as you see it, to the end that you may speak in a natural voice, at a convenient distance from it. Obviously, to start it and stop it, you sit by it; you do not sit at the other side of the room. The best results by far are those which come from speaking into the phonograph in an ordinary conversational tone.

To a newspaper man, or anyone who has work of that kind to do, it is invaluable. Anybody who has to turn out every day a certain quantity of work knows the difference between working when you are ready for it, and having to work when you are not ready but must do so, because somebody is there who is waiting for you, and whose time is valuable. I know myself what it is, and I am sure many in this room do so also. Here is another illustration of a man who is a bookworm. He is reading some very abstruse work on some philosophical subject, surrounded by books, and has the phonograph in front of him. He is looking at his books, and whenever he comes to something which he wishes to make a note of he has not to put down the work and take up pen and paper; all he has to do is to turn the screw and hear the phonograph saying, "I am ready, sir." He speaks into the end of the tube, goes on reading and makes his extract *viva voce*, to be written out subsequently either by himself or by another.

Here is another illustration, of a candidate who is making a speech, possibly practising for a future occasion. Nobody knows his own voice until he has heard it back from the phonograph. It is a surprising thing to anybody to hear his voice for the first time as it is, and not as he fancies it. My observation is that most people are rather pleased with their voices when heard in the phonograph, because when you speak you are making noises inside your own head, and consequently vibrating the diaphragm of the ear from within as well as without. I am told that actors use them for the purpose of improving their elocution, and in that it is a great help. I have a direct illustration of the kind in my own house. I have some phonographs which I call *passé* already, which I allow the children to use, and they have them in the school-room. The other day, I saw a record, and on listening to it, I found it was the voice of one of my little boys leaving a message for his little brother. A boy of ten leaving a message for a boy of seven, and he said, "I wish when you speak into the phonograph, you would be careful to articulate more distinctly," showing that it very much improves the articulation of the school-room.

You may do this with the phonograph. You may make a speech—we will assume that you want to make your speech and to repeat it for correction. First of all you make it; you are not satisfied with it; you want to correct it. You may have two phonographs in that case; you may make your speech in one, and hear it given back sentence by sentence, and observing the improvements you would like to make, you re-make your speech into the other, and have it finally as you like it, without ever having made an erasure or alteration with the pen. It may then be committed to memory or written out for subsequent reading.

Here is another picture, showing the making of musical records at my house for Mr. Edison. In the gallery is the phonograph, to which is attached a long tin funnel, the open end of which is suspended over the musicians playing the violin, organ, piano, and banjo. Here is another little illustration. That is my daughter, and it shows how several pieces of music have been learned in this country in my house from piano music which has been played in America, in the presence of a phonograph recorded on a phonogram, and sent by mail, or by some friend coming to this country. It has been put on my phonograph, repeated in my music-room, at the will of the child who chooses to learn it in that way. The next is rather a touching picture. I show it because it exhibits in a very impressive way what this phonograph can do. There is my young boy, seven years old, sitting down in the front of the phonograph. He is talking a little message to his grandmother, at the time when she was at the point of

death in America, and she in America was to hear the actual voice of her little grandchild in Europe.

The next picture I show you because it is unique in its way. It is not a factory, as you might suppose, where steam-engines or locomotives are made, it is the laboratory and private workshop of a private man, if I can call Edison a private man. At the end is his library, which is 75 feet across and holds 100,000 volumes. When I was last there, there were actually going on in that laboratory 55 different experiments, employing over 100 men, and his pay roll amounted to £200 a week, while in his store rooms he had experimental material to the value of £50,000.

I have already made clear to you that this instrument was not made to talk to anybody who is at a greater distance than sitting comfortably in a chair with his or her feet under the table, and placed in communication with the phonograph by means of these little rubber tubes. It is very important that you should not go away with a mistaken idea of what the phonograph can do. It can do enough without my claiming for it more than it really does. When you hear it speak through this tin trumpet, you will hear it with its voice distorted, as you would hear my voice speaking through the same. This box contains one or two blanks and records from my first phonogrammic cabinet, as I call it, which is a marvellous library of voices. At the present time, some of the most distinguished men in England and Europe have done me the honour to leave behind them the most pleasant possible mementoes of their visits, in a form which enables me to enjoy their invisible company whenever I am in the humour.

It is curious to see how the most distinguished speakers, members of Parliament, members of the House of Lords, the most brilliant speakers behave when they find themselves in front of the phonograph, and speak into it, and realise they are speaking into a mass of iron and steel which will presently fire back the words into their faces. I do not know how it is, but the fact is very curious. I was never so amazed as to see Mr. Irving attack the subject. He walked up to it with that air of confidence which characterises Mr. Irving when he walks. When he stopped walking, he found himself in front of the phonograph, and began to talk into it, but it was not Irving in the least. Some of his oldest friends there said, "Why, my dear Irving, it was not you who spoke," and it was not Mr. Irving himself; absolutely he was frightened out of his own voice. I had actually to put him through his paces to train him for it, to make him walk backwards and forwards a bit, and when he had got into the swing he finally came up and said something which was truly delightful, both when it went into the phonograph and when it came out of it. On a more recent occasion one of the most distinguished statesmen of this country, one whose eloquence has electrified his generation, recently spoke into it. He spoke into it with perfect naturalness, and by means of the phonograph his voice may now be heard by his admiring kin across the sea.

[Colonel Gouraud then proceeded to give various illustrations of the power of the phonograph, by making a short speech into it, dictating a letter, leaving a message for a stockbroker, speaking in French, and in broken English, whistling, singing, laughing, and crying—all of which sounds were reproduced, although, as he had stated, the tone was considerably altered by passage through the speaking-trumpet, which was used in order to make the sounds audible to the audience. He also put into the instrument several phonograms, some of which had come from America, including the sound of a band, followed by the cheering of the audience. He also showed how, by turning a screw, the voice might be moderated in repeating words which had been uttered too loudly in the first instance.]

The CHAIRMAN then proposed a vote of thanks to Colonel Gouraud, which was carried unanimously.

After the meeting a number of members were enabled to test the phonograph practically by the use of two instruments, which were placed in the Council-room. A great variety of phonogram records made in America, both instrumental and vocal, recitations, &c., were shown.

Miscellaneous.

THE LIQUOR TRADE IN NORTHERN AFRICA.

The Belgian Legation at Constantinople has recently addressed a report to the Ministry of Foreign Affairs, in Brussels, on the subject of the trade in alcoholic and other beverages in Northern

Africa. It is stated in this report that the sole obstacle to the development of this trade in the East is the command of the Koran strictly forbidding the use of wine. Beer and other similar beverages are found in great quantities in the ports of Northern Africa—at Tunis, Tripoli, Bengazi. Alexandria, Port Said, and Suez, while as regards wine, it is only found where European colonies are established. In Tunis, which up to the date of the French occupation was a centre of fanatic Mahometanism, the importation of beverages has progressed very slowly. During the decennial period, 1862-1871, the value of the total imports amounted to 31,000 florins, making an average annual value of 3,000 florins; since the occupation it increased until the quantity imported in 1884 rose to 3,334,083 bottles. In Tunis, French and Italian wines are found, while Austria is represented by spirits and mineral waters, and it is stated that if a regular transport service were organised between Trieste and Tunis the export of Austrian spirits would greatly increase. In this case there would be little to be feared from the competition of German and American spirits, which now come to Tunis *viâ* Marseilles. In Tripoli the drink traffic is more restricted than in Tunis, and this may in some measure be due to the absence of the necessary ways of communication. The annual value of the imports may be estimated in round numbers at 100,000 francs. To this value the United Kingdom contributes in the proportion of 12 per cent., Italy 20 per cent., France 55 per cent., and Austria-Hungary 11 per cent. The latter country exports beer very largely, which comes generally from Trieste and Graz; and malt liquors are also received from France and Germany, but to a very inconsiderable extent. A small quantity of English stout in barrels is imported. Alcohol is almost exclusively an article of Austro-Hungarian importation. The Mahometan population annually consume alcoholic beverages, coloured and highly perfumed, to the value of from 15,000 to 20,000 francs. Finally, wine in bottles comes from France and Italy, but that which is in greatest demand is Sicilian wine, which is imported in casks. Bengazi is somewhat more removed from the international traffic, but its Mahometan population use spirits in as great quantities as the population of Tripoli. The annual consumption varies between 100,000 and 120,000 francs. The importations are effected by English, Italian, and Turkish vessels, and no returns exist which show the part borne by the various European States in this trade. In Egypt, where the European population is very great, and where, moreover, the Mahometan population have acquired a taste for spirituous liquors, the consumption of the latter is very considerable. Alexandria naturally holds the first rank as regards an importing centre. The importation of beer only commenced to assume any mportance in 1863, and consequent upon the rapid ncrease in the prosperity of the European colony it attained its maximum in 1865—600 eimers a week (the eimer being equivalent to forty-five quarts). The American War crippled trade generally, and the imports of beer fell off very considerably, and for some time have varied between 360 and 450 eimers per week, taking summer and winter together. Since, however, the opening of the Suez Canal the trade has greatly increased—it amounted to 198,000 gallons in 1879, and in 1884 to 330,000 gallons. Austria, which at the commencement had to compete with Bavarian, Swedish, and English beer, now holds the first rank as an exporting country to Alexandria, owing in great measure to the system of rapid transport, and the advantages of Trieste and Fiume from a geographical point of view. Independently of this, the Austrian beers are much preferred for the reason that they contain less alcohol than others, and are cousequently less hurtful in view of the climate. The English garrison at Alexandria is the cause of large quantities of English and Danish beer arriving, but as these, although of better quality than the Austrian, are much higher priced, there is not such a large demand for them. It is stated as a curious fact that economic crises do not appear to exercise any appreciable effect upon the consumption of beer. As regards spirits, there is a large importation into Alexandria. The value of the Austro-Hungarian imports amount annually to between 100,000 and 150,000 florins. Considerable apprehension has been caused among Austrian exporters by the rapidly-increasing imports of Russian spirits, more especially since 1883, the latter being preferred to the Austrian products on account of their purity and good flavour. The imports of wine into Alexandria are considerable. Egypt buys her wines from Italy, Greece, France, and Austria-Hungary. If the table wines of Italy and Greece are preferred to the others, this circumstance is due to the fact that Italians and Greeks predominate among the European colony in the town. Among the Italian wines those from Tuscany, Naples, and Sicily are highly appreciated, while as regards the French products, Saint Estephe, Margaux, and Chateau Terrefort are most in demand. The greatest share of the imports is taken by the Greeks, who send Cyprus wine, the extraordinary cheapness of which defies all competition. The following is a statement of the prices of the different wines, imported, on the market at Alexandria:—Neapolitan from 2 to $2\frac{1}{2}$ piastres the oke (the oke is equivalent to about one quart), Tuscan from $2\frac{1}{4}$ to $2\frac{1}{2}$ piastres, Sicilian from $1\frac{3}{4}$ to 2 piastres, Greek table wine from $\frac{1}{2}$ to 1 piastre, French from 2 to $2\frac{1}{2}$ piastres, Cyprus from 1 to $1\frac{1}{2}$ piastres, Dalmatian from $2\frac{1}{4}$ to $3\frac{1}{2}$ piastres, and Hungarian from $3\frac{1}{4}$ to 4 piastres per oke. The imports of Austro-Hungarian mineral waters is increasing in a remarkable manner, and very large quantities are consumed during the hot season. The Austrian descriptions in greatest demand are Giesshubler, Rohitch, and Pilnau,

while the Hungarian are the Hunyadi Yanos and Rakoczi. Cairo is an important market for Austro-Hungarian beer; the average importation per week is estimated at 8,800 gallons in barrels, and 60 cases containing 48 bottles each. Hungarian wines are much appreciated at Cairo, and the value of the annual importation amounts to about 6,000 gold florins. Since 1884, Dalmatian wine has appeared on the Cairo market, and is preferred to the Greek, but the price is higher. The imports of beverages at Port Said amounts to between 3,000 and 4,000 tons annually, to which Austria-Hungary contributes from between 10 and 15 per cent. As regards wine, Greece and France obtain the preference. Suez obtains her wines and spirits from France, Austria-Hungary sending beer to the amount of about 440,000 pounds weight annually.

Obituary.

W. G. PEDDER, C.S.I.—Mr. William George Pedder, late Revenue Secretary to the India Office, died on Wednesday, the 21st inst., at his residence at West Dulwich. Mr. Pedder, a son of the Rev. W. N. Pedder, vicar of Clevedon, was born in 1832, and married in 1863 Julia, daughter of Colonel Prescott, of the Bombay Army. Mr. Pedder was employed in the Bombay Civil Service from 1856 to 1879, being engaged in the departments of revenue, statistics, and commerce. In 1879 he was appointed Secretary of the Correspondence Department of the India Office, an office which he resigned last year. Mr. Pedder was elected a member of Council of the Society of Arts in 1883, and remained on the Council until October, 1886, when he resigned on account of ill health. He was an active member of the Society, and frequently presided and joined in the discussions at the evening meetings. In April, 1883, he read a paper on the "Historical development of the different settlement systems of British India," for which he received the Society's silver medal, and in the following year he read a paper on "The Existing Law of Landlord and Tenant."

MEETINGS OF THE SOCIETY.

ORDINARY MEETING.

DECEMBER 5.—"The Graphophone." By HENRY EDMUNDS. W. H. PREECE, F.R.S., will preside.

DECEMBER 12.—"Explosives." By W. H. DEERING, F.C.S. SIR FREDERICK ABEL, C.B., D.C.L., F.R.S., President of the Government Commission on Explosives, will preside.

DECEMBER 19.—"Standards of Light." By W. J. DIBDIN, F.I.C., F.C.S.

Papers for which no dates have as yet been fixed:—

"Manufacture of Sèvres Porcelain." By EDOUARD GARNIER (late of the Sèvres Manufactory).

"The Forth Bridge." By BENJAMIN BAKER, M.Inst.C.E.

"The Channel Tunnel." By COLONEL HOZIER.

"Salt." By PETER LUND SIMMONDS.

"The Construction of Photographic Lenses." By CONRAD BECK.

"The Manufacture of Aluminium." By WILLIAM ANDERSON, M.Inst.C.E.

"Automatic Selling Machines." By J. G. LORRAIN.

"Secondary Batteries." By W. H. PREECE, F.R.S.

"Arc Lamps and their Mechanism." By Prof. SILVANUS P. THOMPSON.

"The Irish Lace Industry." By ALAN S. COLE.

"The Use of Spirit as an Agent in Prime Movers." By A. F. YARROW.

FOREIGN AND COLONIAL SECTION.

The meetings of this Section will take place on the following Tuesday evenings, at Eight o'clock:—

January 29; February 19; March 12; April 2, 30; May 21.

INDIAN SECTION.

The meetings of this Section will take place on the following Friday evenings, at Eight o'clock:—

January 25; February 15; March 8, 29; May 3, 24.

APPLIED ART SECTION.

The meetings of this Section will take place on the following Tuesday evenings, at Eight o'clock:—

January 22; February 5, 26; March 19; April 9; May 14.

CANTOR LECTURES.

The following courses of Cantor Lectures will be delivered on Monday evenings at Eight o'clock:—

Captain W. DE W. ABNEY, C.B., F.R.S., "Light and Colour." Four Lectures.

LECTURE II.—DECEMBER 3.—Production of colour by absorption; by fluorescence.—The measurement of the luminosity of colours.—The effect of the dilution of colours.—Colour contrast.—Colour-blindness.

LECTURE III.—DECEMBER 10.—Mixtures of colours.—Impure colours.—Effect of ground in water colours.—The measurement of colour in terms of a standard.—The reproduction of the colours of a pigment.

LECTURE IV.—DECEMBER 17.—The action of light on pigments.—The cause of change.—The effect of sunlight, sky-light, and artificial light.—Rays effective in causing change.—Moisture and oxygen necessary to cause change.

ALAN S. COLE, "Egyptian Tapestry." Two Lectures.
January 21, 28.

W. J. LINTON, "Wood Engraving." Two Lectures.
February 11, 18.

WALTER CRANE, "The Decoration and Illustration of Books." Three Lectures.
March 4, 11, 18.

C. V. BOYS, F.R.S., "Instruments for the Measurement of Radiant Heat." Four Lectures.
March 25; April 1, 8, 15.

H. GRAHAM HARRIS. M.Inst.C.E., "Heat Engines other than Steam." Four Lectures.
May 6, 13, 20, 27.

JUVENILE LECTURES.

Two Juvenile Lectures, entitled "How Chemists Work—an example to Boys and Girls," by HENRY E. ARMSTRONG, Ph.D., F.R.S., will be given on Wednesday evenings, January 2 and 9, 1889, at Seven o'clock.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, DEC. 3...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Captain W. de W. Abney, "Light and Colour." (Lecture II.)

Farmers' Club, Salisbury-square Hotel, E.C., 4 p.m. Major Craigie, "The Farmers' Labour Bill."

Royal Institution, Albemarle-street, W., 5 p.m. General Monthly Meeting.

Chemical Industry (London Section), Burlington-house, W., 8 p.m. Mr. A. H. Allen, "Analytical Examination of Water for Technical Purposes."

British Architects, 9, Conduit-street, W., 8 p.m. Mr. Francis Hooper, "Building Control in Paris."

Medical, 11, Chandos-street, W., 8½ p.m.

Victoria Institute, 7, Adelphi-terrace, W.C., 8 p.m. Rev. Henry George Tomkins, "Some of the Principal Races mentioned in the Bible."

London Institution, Finsbury-circus, E.C., 5 p.m. Prof. S. Thompson, "The Colours of Polarized Light." (Lecture I.)

TUESDAY, DEC. 4...Civil Engineers, 25, Great George-street, S.W., 8 p.m. J. Oliver Arnold, "The Influence of Chemical Composition on the Strength of Bessemer Steel Tires."

Pathological, 53, Berners-street, Oxford-street, W., 8½ p.m.

Biblical Archæology, 9, Conduit-street, W., 8 p.m.

Zoological, 11, Hanover-square, W., 8½ p.m. 1. Mr. Oldfield Thomas, "On the Mammals obtained by Mr. C. M. Woodford during his second expedition to the Solomon Islands." 2. Mr. Frank E. Beddard, "Certain Points in the Structure of *Clitellio* (Claparède)." 3. Prof. G. B. Howes and Mr. A. M. Davies, "The Distribution and Morphology of the Supernumerary Phalanges in the Anura." 4. Mr. J. J. Lister, "The Natural History of Christmas Island, Indian Ocean."

WEDNESDAY, DEC. 5...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. Henry Edmunds, "The Graphophone."

Geological, Burlington-house, W., 8 p.m. 1. Prof. T. G. Bonney, "Notes on Traverses of the Crystalline Rocks of the Alps." 2. Mr. Frank Rutley, "Fulgurites from Monte Viso." 3. Mr. T. T. Groom, "The Occurrence of a new form of Tachylyte in association with the Gabbro of Carrock Fell, in the Lake District."

Entomological, 11, Chandos-street, W., 7 p.m. 1. Lord Walsingham, "Monograph of the genera connecting *Tinæogeria*, Wlk., with *Eretruocera*, Z." 2. Mr. Frederic Merrifield, "Incidental Observations in Pedigree Moth Breeding." 3. Rev. F. A. Walker, "Description of a variety of *Ornithoptera Brookiaria*." 4. Rev. T. A. Marshall, "Monograph of British *Braconidæ*." (Part III.)

Obstetrical, 53, Berners-street, W., 8 p.m.

Inventors' Institute, 27, Chancery-lane, W.C., 8 p.m. 1. Rev. J. M. Taylor, "The latest form of Oarsman Tricycle." 2. Mr. H. Wilson, "The Rocket Bicycle, and its rudder or castor steering gear."

Civil and Mechanical Engineers, Westminster Palace Hotel, S.W., 7 p.m. Inaugural Address by the President.

Central Chamber of Agriculture (at the HOUSE OF THE SOCIETY OF ARTS), 11½ a.m. Annual General Meeting.

THURSDAY, DEC. 6....Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

Linnean, Burlington-house, W., 8 p.m. 1. Dr. J. C. Costerus, "Malformation in *Fuchsia globosa*." 2. Dr. B. T. Lowne, "The Development of the Egg and Blastoderm of the Blowfly." 3. Mr. G. A. Boulenger, "The Reptiles and Fishes of Fernando Noronha."

Chemical, Burlington-house, W., 8 p.m. 1. Ballot for the Election of Fellows. 2. Dr. W. Bott, "A method of determining Vapour Densities applicable at all temperatures and pressures." 3. Dr. W. Bott and J. Bruce Miller, "Derivatives and some new Colouring Matters obtained from *a*. Pyrocresol." 4. Dr. S. Rideal, "The Action of Ammonia on Tungsten Oxychlorides." 5. Mr. G. C. McMurtry, "Thiomyl Thiocyanate." 6. Mr. G. C. McMurtry, "Mercuric Chlorothiocyanate."

London Institution, Finsbury-circus, E.C., 6 p.m. Prof. S. R. Gardiner, "Political Progress in the 17th Century."

Sanitary Institute, Parkes Museum, 74A, Margaret-street, Regent-street, W., 5 p.m. Sir Douglas Galton, "The Future of the Amalgamated Societies—the Parkes Museum and Sanitary Institute of Great Britain."

Archæological Institution, 16, Burlington-street, W. 4 p.m.

FRIDAY, DEC. 7...Geologists' Association, University College, W.C., 8 p.m. 1. Mr. J. Logan Lobley, "The Causes of Volcanic Action." 2. Mr. J. G. Goodchild, "Some Observations upon the Mode of Occurrence and Origin of Metalliferous Deposits."

SATURDAY, DEC. 8...Physical Science Schools, South Kensington, S.W., 3 p.m. Mr. T. H. Blakesley, "Some Facts connected with Systems of Scientific Units of Measurement."

Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m.

Journal of the Society of Arts.

No. 1,881. Vol. XXXVI.

FRIDAY, DECEMBER 7, 1888.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

THE GRAPHOPHONE.

Mr. Edmunds has consented to allow the instruments exhibited on the occasion of the reading of his paper on the "Graphophone," on Wednesday evening, 5th inst., to remain at the Society's house for exhibition to members on Thursday, Friday (10 to 4), and Saturday (10 to 2). Colonel Gouraud has also sent a phonograph, which will be exhibited during the same time. Members will be admitted on signing their names. Any member can introduce personally two friends. Nobody who is not a member or accompanied by a member can be admitted.

INDIAN SECTION COMMITTEE.

A meeting of the committee of the Indian Section was held on Thursday, 29th November, at 4 p.m. Present:—Sir George Birdwood, K.C.I.E., C.S.I., LL.D., M.D., in the chair, Colonel Sir Owen Tudor Burne, K.C.S.I., C.I.E., Mr. Hyde Clarke, Major-General Sir Frederick Goldsmid, K.C.S.I., C.B., Major-General J. Michael, C.S.I., with Mr. H. Trueman Wood, Secretary of the Society, and Mr. Demetrius Boulger, Secretary of the Section. The programme of papers to be read during the present Session was discussed.

FOREIGN & COLONIAL SECTION.

A meeting of the Committee of the Foreign and Colonial Section was held on Wednesday, December 5th, at 4 p.m. Present:—Mr. Hyde Clarke, in the chair, Colonel Sir Owen Tudor Burne, K.C.S.I., C.I.E., Mr. P. L. Simmonds, Mr. B. Francis Cobb, Colonel A. C. Hamilton, R.E., with Mr. Trueman Wood, Secretary of the Society, and Mr. E. Cunliffe-Owen, C.M.G., Secretary of the Section. The programme of papers to be read during the present Session was discussed.

PRIZES FOR ART-WORKMEN.

Prizes are offered to Art-workmen in the following classes:—

I.—Pottery (including Porcelain and Earthenware).

1. The Body, any material.
   - *a.* Thrown, not shaved, first prize, £5; second prize, £2.
   - *b.* Shaved or turned, first prize, £5; second prize, £2.
2. Decoration.
   - *a.* Modelled and glazed, first prize, £10; second prize, £5; third prize, £3.
   - *b.* Painted under glaze, first prize, £10; second prize, £5; third prize, £3.
   - *c.* Enamel on the glaze, first prize, £10; second prize, £5; third prize, £3.
3. Stone salt-glazed ware.
   - *a.* Plain; incised and glazed, first prize, £10; second prize, £3; third prize, £3.
   - *b.* Coloured or otherwise decorated, first prize, £10; second prize, £3; third prize, £3.

The Art-workman must have designed the body of the pot as well as have executed the decoration.

All the specimens of pottery sent in for competition must be dated on the clay.

II.—Stone Carving.

First prize, £25; second prize, £15; third prize, £10; fourth prize, £5.

The capital of a column, with square, circular, or octagonal abacus, not to exceed twelve inches in width.

III.—Wrought-Iron Grilles.

First prize, £25; second prize, £15; third prize, £5.

A grille measuring not less than three feet superficial, nor more than five feet superficial.

The object for which the grille is intended must be stated—whether for a protective purpose, for the outside of a window, for a street-door panel, or for indoor use as a window screen, coil case, ventilator, &c.

IV.—GOLDSMITHS' AND SILVERSMITHS' WORK.

[Prizes presented by the Goldsmiths' Company.]

A cup or sugar basin of beaten silver, chased or otherwise, made within the year 1888. First prize, £20; second prize, £5.

A pendant or brooch, or locket of gold without gems. First prize, £20; second prize, £5.

All articles for competition must be sent in to the Society's House on or before Tuesday, April 23rd, 1889.

The conditions under which these prizes are offered have appeared in previous numbers of the *Journal*.* They can also be obtained on application to the Secretary.

Proceedings of the Society.

THIRD ORDINARY MEETING.

Wednesday, December 5th, 1888; Colonel SIR OWEN TUDOR BURNE, K.C.S.I., C.I.E., in the chair.

The following candidates were proposed for election as members of the Society:—

Cole, Henry Ean, 1, St. James's-place, S.W., and The Cottage, Usk.
Jennings, George Henry, Westdene, Pendennis-road, Streatham, S.W., and Palace-wharf, Stangate, S.E.
Pope, Alex. 5, John-street, Adelphi, W.C., and Methven-house, King's-road, Kingston on-Thames.
Scott, Archibald, South Bank, Surbiton, Surrey.
Woodhouse, A. E. C., M.R.C.S., 1, Hanover-square, W.

The following candidates were balloted for and duly elected members of the Society:—

Agnew, Charles Morland, M.A., 39B, Old Bond-street, W.
Bailey, Richard, 12, Leazes-place, Durham.
Bartholomew, Charles William, Blakesley-hall, near Towcester, Northamptonshire.
Bonus, Major-General Joseph, The Cedars, Strawberry-hill, Twickenham.
Brown, Thomas, King's Lynn, Norfolk.
Brown, William, 67, Renfield-street, Glasgow.
Buckeridge, Herbert Leighton, Leighton-villa, Cheverton-road, Hornsey-lane, N.
Bush, William Ernest, 21, Artillery-lane, E.
Butler, William Waters, Crown Brewery, Birmingham.
Cart, Rev. Henry Thomas, Oakhurst, Upper Norwood, S.E.
Cecil-Johnson, Colonel Edmund, United Service Club, Pall Mall, S.W.
Chalmers, Alexander B., Scottish Club, 39, Dover-street, Piccadilly, W.
Clapham, W. W., 35, Church-street, Manchester.
Cochran, Alexander, 22, Blythswood-square, Glasgow.
Cook, Henry John, The Firs, Woodford, Essex.
Corbett, James Andrew, Castle-street, Cardiff.
Cotterill, William, Tongswood, Hawkhurst.
Craig, James, Llyndally, Palace-road, Tulse-hill, S.W.
Cunningham, Hon. Justice, 6, Onslow-gardens, S.W.
Daniell, John Henry, 4, Lombard-street, E.C.
De Negri, Charles, 68, Stamford-street, S.E.
Derham, Benjamin, M.D., 110, St. George's-road, Bolton-le-Moors.
Edmunds, Henry, 10, Hatton-garden, E.C.
Filliter, Edward, 3, Rosslyn-hill, Hampstead, N.W.
Freeman, Francis, 63, Pall Mall, S.W.
Gedge, Alfred Sydney, 3, Great James-street, Bedford-row, W.C.
Gilbert, Josiah, Marden Ash, Ongar, Essex.
Gow, John, St. Julian's-road, Streatham, S.W.
Haas, Hendrik C. 32, Fenchurch-street, E.C.
Hall, Samuel, 19, Aberdeen-park, Highbury, N.
Haller, George, 86, Leadenhall-street, E.C.
Hammersley, Hugh Greenwood, 6, Chelsea-embankment, S.W.
Hardy, George Francis, 5, Whitehall, S.W.
Harris, William A., Phœnix-chambers, Exchange, Liverpool.
Hartland, W. H. Hill, 114, Hyde-park-street, Glasgow.
Harvey, Thomas Morgan, 1, Gresham-buildings, Basinghall-street, E.C.
Heap, Ralph, jun., 1, Brick-court, Temple, E.C.
Heighway, Thomas, 19, John Dalton-street, Manchester.
Herbert, Wilfrid V., 40, Scarsdale-villas, Kensington, W.
Hewetson, Frank, Grove-house, Sutton, Surrey.
Hinds, James, 127, Gosford-street, Coventry.
Jackson, Richard Charles, Grosvenor-park, Camberwell, S.E.
Jekyll, H. H., Lincoln.
Jonas, John J., St. Stephen's Club, Westminster, S.W.
Jones, John James, Brent-house, Devonshire-road, South Hackney, E.
Jones, Joseph, Free Library, Wolverhampton.
Kemsley, Jesse, Rodwell-villa, Rodwell-road, East Dulwich, S.E.
Kidner, William, 23, Old Broad-street, E.C.
Knill, Henry Hughes, 37, Cheapside, E.C.
Leith, J., The Grove, Knowsley-road, St. Helen's, Lancashire.
Littleton, Augustus, Westwood Field, Sydenham, S.E.

* See *Journal*, June 15.

Lynam, Henry M., Shelton Colliery and Ironworks, Hanley, Staffordshire.
MacDougall, Robert, 67, Renfield-street, Glasgow.
Marks, David, 4, Cornwall-mansions, South Kensington, S.W.
Molloy, William R. I., 17, Brookfield-terrace, Donnybrook, Co. Dublin.
Moul, Frank, Aldersgate Chemical Works, Southall, Middlesex.
Page, Herbert William, F.R.C.S., 146, Harley-street, W.
Pain, James, Saint Mary-street, Ely, Cambridgeshire.
Pape, Edward James, 67, Great Clyde-street, Glasgow.
Parker, Archibald, Camden Wood, Chislehurst, Kent.
Partridge, Henry Francis, L.D.S., 43, Sussex-place, Old Brompton-road, S.W.
Perry, Rev. S. J., S.J., D.Sc., F.R.S., Stonyhurst College Observatory, Lancashire.
Pratt, Benjamin, 1, Wood-street, E.C.
Probyn, Lesley Charles, 79, Onslow-square, S.W.
Rae, George, Redcourt, Birkenhead.
Reeve, William John, Camborne, Cornwall.
Ridgway, John, Heath-house, Cheddleton, Leek.
Rooke, William, 11, Milk-street-buildings, E.C.
Rooper, Thomas Godolphin, 13, Lindum-terrace, Bradford.
Searell, Thomas, Fitzroy, Melbourne, Victoria, Australia.
Shaw, William, 2, Pembroke-road, Kensington, W.
Sherrin, John Vaughan, 3, Codrington-road, Ramsgate.
Smith, James W., Totnes-house, Cawley-road, South Hackney, E.
Stapleton, Edward John, 28, Davies-street, Berkeley-square, W.
Strachey, Sir John, G.C.S.I., C.I.E., 37, Cornwall-gardens, S.W.
Strong, Alfred, 7, John-street, Adelphi, W.C.
Taylor, Henry William, Wallington-cottage, Carshalton, Surrey.
Taylor, William, Hague Bar Board Schools, New Mills, Stockport.
Temple, Thomas Ramshay Smyth, 8, Norfolk-crescent, Hyde-park, W., and Ellerslie, Chichester.
Trotter, William, 24, Prince's-gardens, S.W.
Venn, Charles Augustus, 57½, Coleman-street, E.C.
Walker, Archibald, M.A., 8, Crown-terrace, Glasgow.
Wallace, Prof. Robert, The University, Edinburgh.
Waterer, Clarence, Ingle-cottage, Addlestone, Surrey.
Watson, George Coghlan, Ashburton, Brigstock-road, Thornton-heath.
Whinney, Frederick, 8, Old Jewry, E.C.
Wilkinson, James Herbert, 9, Priory-place, Doncaster.
Wills, Rev. Freeman, M.A., Ferndale-road, Clapham, S.W.
Wiltshire, Ernest William, 25, Granville-park, Lewisham, S.E.
Wiltshire, Rev. Professor Thomas, M.A., 25, Granville-park, Lewisham, S.E.
Wormald, James, Woodville-road, Cathays, Cardiff.

The paper read was—

THE GRAPHOPHONE.*

BY HENRY EDMUNDS.

One of the chief distinctions between man and the brute is the faculty of articulate speech. Human civilisation could not have been built up or maintained without it. Spoken language is, however, in its very nature evanescent. Accordingly, at an early period we find men endeavouring to fix and record their ideas in some form or other, and we might spend much time most profitably in reviewing the progress and development of the art of recording, by signs and writing, human speech, but that is a field too wide for our consideration just now. Suffice it to say that our present system of alphabetical writing has been the result of centuries of growth, aided and moulded by the foremost intellects of every generation. Alphabetic writing, however, with all its beauty, and all its advantages, does not quite fulfil all the requirements of the age. It is not sufficiently rapid to catch and photograph the fleeting word or thought, and systems of stenography have had to be invented to supply this defect. Then, again, although alphabetic writing can record man's words, it cannot record the manner in which they are uttered. But the instrument which I will exhibit to you to-night marks a fresh epoch in the history of human culture. A few mechanical movements can produce results far superior to the most perfect system of writing yet invented, and the human voice can be received, recorded, and reproduced, with all the tones and inflections that distinguish the living word from the dead letter.

Before describing the instrument which renders these things possible, it will be well to indicate something of the steps which have led up to it. An invention seldom comes from the brain of one inventor perfect in all its parts; and we generally find that there are several workers in the same field, sometimes on the right track, but more often very much astray, until the right man appears to demonstrate the proper method of arriving at the

* The blocks which illustrate this paper have been obligingly lent by the Editor of *Engineering*.

desired result. This has been the case with the graphophone.

Thirty years ago Leon Scott invented a machine, which he called the phonautograph, for the purpose of recording upon paper a graphic representation of the sounds made by the human voice. In this instrument, a sheet of paper was wrapped round a cylinder; a fine coating of carbon was deposited upon it by means of a smoky flame, and then the cylinder was revolved before a membranous diaphragm, carrying a stylus in its centre. On speaking or singing against this diaphragm, the stylus was agitated, and so traced an irregular spiral line upon the surface of the cylinder by removing the particles of carbon with which it came in contact. This irregular spiral line then formed a visible representation of the vibrations of the diaphragm under the influence of the voice. But though the phonautograph gave visible records of sounds, it did not reproduce them. Professor Bell, in the telephone, showed how vibrations received from the voice on one diaphragm could be electrically transmitted and reproduced audibly on another at a distance. This suggested to an observant Frenchman, named Charles Cros, the idea not merely of transmitting but of recording and reproducing the human voice. He proposed to take a Scott phonautograph, and transfer its traced undulatory spiral by means of photography and electro-metallurgy to a copper or steel plate. Then, by revolving this metal plate before a second diaphragm carrying a stylus in its centre, the undulations in the plate would be communicated as vibrations to the diaphragm, and so reproduce whatever had been originally spoken. On the 30th of April, 1877, Monsieur Cros deposited at the Academy of Sciences, in Paris, a sealed paper, entitled "A process of recording and of reproducing audible phenomena," in which he stated his ideas, and proposed several methods of carrying them into effect. This paper was duly read, and will be found in their proceedings. Therefore, to M. Cros we must accord the honour of having first conceived a feasible plan for mechanically reproducing speech once uttered. But, in this case, the man who thought was outstripped by the man who worked. Before M. Cros gave practical shape to his idea, Mr. Thomas Alva Edison, later in the year, had brought out an instrument which he called the phonograph.

In the phonograph, a sheet of pliable material, such as tinfoil or waxed paper, was wrapped round a cylinder, and mounted opposite a vibratory diaphragm, so supported that a stylus in its centre pressed upon the same. In operation, the cylinder was rotated spirally, and at the same time that the diaphragm was spoken or sung to, it was thrown into vibration. The stylus of course vibrated with the diaphragm, and thus impressed or indented an irregular undulating furrow upon the foil, forming a sound record approximating more or less closely to the vibrations of the diaphragm. The reproduction of the original sounds depended upon the ability to make the diaphragm repeat its original motions. In accomplishing this, the stylus was set back to the starting point, and the cylinder again rotated. The stylus was thus vibrated by the undulations of the record.

But this instrument was crude and rough, and we must see what steps were made between that and the improved phonograph with all its marvellous beauty which charmed you last week. This brings me to a delicate part of my subject. I wish particularly to avoid any semblance of discussion on the relative merits of the two instruments—the phonograph and graphophone, *per se*; neither do I in any way wish to avert any of the credit due to Mr. Edison. I have been too intimately acquainted with him and his inventions to do other than accord to him his measure of praise. But honour to whom honour is due; and I must now ask you to follow me in finding out not only what the essential difference is between the old phonograph and the improved instrument, but where lay the difference, and who made the discovery which converted an instrument which could only caricature the human voice into such perfect instruments as we see to-day.

The great Napoleon, amid his many imperial enterprises, determined to foster the spirit of discovery and invention in electrical science, and he founded a prize of 40,000 francs, to be awarded by the French Academy of Science to meritorious inventors. This prize was afterwards raised to 50,000 francs, and has been awarded several times during the present century. This Volta prize, as it was called, was awarded to Professor Alexander Graham Bell for his invention of the telephone, and he at once determined to apply the money to further the interests of science. To this end he entered into an arrangement with his cousin, Dr. Chichester A. Bell, and Mr. Charles Sumner Tainter, and they formed themselves, in 1881, into the Volta Laboratory Association,

applying themselves to the study of the art of recording and reproducing sounds.

Mr. Charles Sumner Tainter was born in 1850, and began life as a maker of telegraphic and electrical apparatus. He afterwards worked upon astronomical and other scientific instruments, and his skill in the manufacture and manipulation of these induced the United States Government to commission him to accompany the expedition sent out in 1874 to observe the transit of Venus, when the special charge of all the scientific apparatus was entrusted to him. He afterwards followed his profession as philosophical instrument maker until he became acquainted with Professor Bell. In Mr. Tainter, therefore, there was a man who possessed the requisite scientific and mechanical training to undertake the work in view, and bring it to a successful issue. Professor Bell brought his consummate acquaintance with acoustics, and Dr. Chichester Bell contributed his chemical and electrical knowledge. The Volta Laboratory Association purchased all the apparatus and appliances necessary for their investigations, and worked away for several years with great assiduity, carrying on experiments in every conceivable direction, and carefully recording their experiences, discoveries, and suggestions. The magnitude of their work may be conceived when it is stated that their labours fill no less than thirty volumes, and large sums were expended in these researches. Among other things they set to work to study the action of the original phonograph, and discovered its failure to be due to imperfections which in the light of our present knowledge it is easy to point out. The vibrations of the diaphragm and its stylus are very minute, and nothing but an exceedingly soft and exceedingly pliable substance can be indented or embossed by the point of the style so as to conform precisely to the complex motions of the diaphragm. Moreover, it should be pointed out that, as the point of the style presses upon the foil, it tends to pucker the surface, so that it is practically impossible to indent any such substance as tinfoil or waxed paper with a mark of such defined outlines as will permit of accurate reproduction. Furthermore, in the art of reproduction, as the material is simply impressed or indented, the pressure of the reproducing stylus will, to some extent, obliterate the record, so that each reproduction so alters the surface of the foil that the sounds at length become unrecognisable.

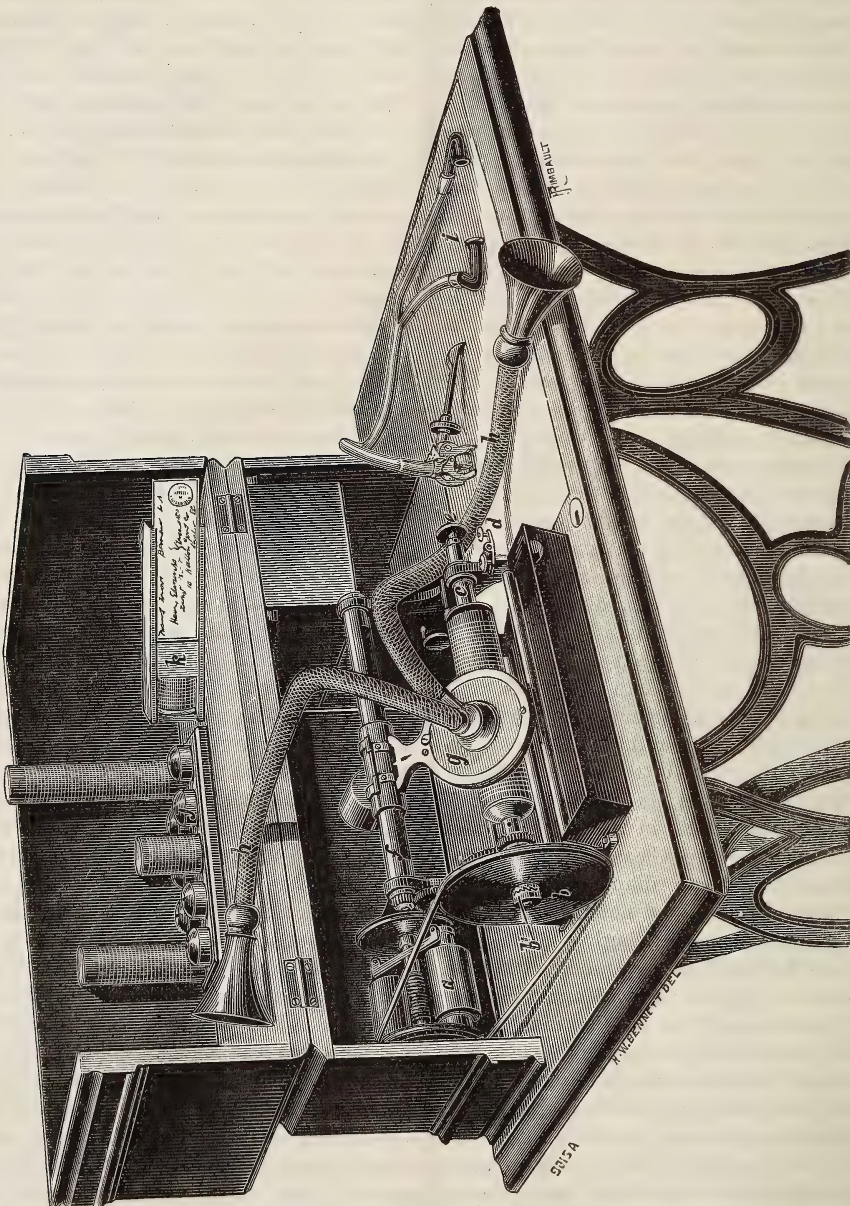
The Volta Association soon perceived that the record, to be permanent, must be engraved in a plate of solid resisting material, and that they had to discover some material which was suitable for the purpose. The field was a large one, and quite unexplored, so that the task was most laborious. Woods, metals, alloys, india-rubber, and various compositions were tried in succession, and at last beeswax was decided upon as offering the greatest advantages. But even this was far from perfect. In the first place, it was too soft; and many experiments had to be made in mixing it with ozokerit, paraffin wax, and other substances, in order to give it the requisite solidity on the one hand, and yet permit of its being easily engraved on the other. But they at last succeeded in obtaining a satisfactory composition, and found themselves within sight of their goal. Now, instead of merely indenting upon a pliable substance, they were able to cut or engrave a permanent record in a solid resisting material, and this entirely new principle of operation enabled them to succeed where indentation had failed. A plate of waxy composition was revolved before a diaphragm carrying a steel point in its centre, taking care that its tip should be beneath the surface of the wax, and thus a shallow groove was ploughed out in the material. Then, as the diaphragm was vibrated under the influence of the voice, the ploughed groove was varied in its depth, leaving a series of minute undulations at the bottom. On going over this groove again with a lighter diaphragm and style, the listeners were delighted to hear the sounds repeated, not indistinctly, but in clear tones as when they were spoken. A practical sound-recording and reproducing machine had at last been invented, which was called the "Graphophone." This was in 1885.

I will now describe to you the principles upon which it works, and show the details for carrying out the same. Sounds have three qualities. Their character, their pitch, and loudness. By character we mean that which the French call *timbre*, that which gives us a distinction between the same note produced either by the voice, a stringed instrument, a reed, or a bell, or a vibrating fork or wire. Pitch is simply the number of vibrations in a given unit of time, and loudness the amplitude of those vibrations.

Now, how are all these qualities in all their infinite diversity and number received, recorded, and reproduced by such simple

means? This brings us to a description of the graphophone, which consists of several parts—the recorder, the reproducer, and the cylinder to receive the sound waves, and the mechanism for rotating the cylinder. We are struck with its extreme simplicity; it has no business to talk; no one would expect the mere combination of a piece of talc or mica, a needle, and a revolving candle, could form the essentials of an instrument which can not

Fig. 1.



The Graphophone.

merely at one operation receive all or any sounds uttered before it but can retain and give back those sounds with a faithfulness undreamed of till experienced, and which at once can convey more clearly to the mind ideas spoken in words than all the elaborate and complex methods of writing that we know of. Let us see why it can do this. There can be no sound without motion, nor can we convey sound except through the

medium of something which can be moved, though that medium may not appear in motion. The ear, however, can detect movements which the eye fails to see. This is clearly shown in the telephone; there the small iron disc may be vibrating in unison with words spoken but only the ear can detect these vibrations, translating them into speech.

We have here a beautiful demonstration of this. In the room below is a musical box, which is playing tunes and producing sounds which are producing movements or vibrations in the media surrounding it. When we let this wooden rod rest on the box, the vibrations are conveyed to it, but are not visible or audible to you until we cause this large piece of wood to be vibrated, when each one may hear the sounds throughout this room. This experiment shows how sounds can be transmitted and reproduced by vibrations. It is by no means a new one, and is akin to the old mechanical telephones, where a piece of string connecting two pill boxes drawn tightly could convey speech from persons whispering to each other at a distance, and yet these plain indications of the simple requirements to convey and reproduce sounds lay for years unapplied either as in the telephone or phonograph.

As I have remarked, the graphophone consists of several parts, the recorder, the reproducer, and the cylinder. The recorder consists of a diaphragm which has only a to-and-fro motion, and the cutter and graver thereon is only a single point. The graver can only vibrate through a small distance, varying the depth of the groove it is cutting in the revolving wax cylinder; remember the cylinder must be revolving all the time at a velocity sufficient to present a new surface to the cutting style as each new vibration is received.

We have here a crude method of showing you what takes place. Here is a disc representing a section of the cylinder. This we will rotate under a cutting style, it will at the same time be vibrated as by the voice, cutting, as you will see, a series of hills and dales corresponding to the sound waves striking the diaphragm. Now, let us look at these waves; they are irregular as to length, that is pitch, and depth, that is loudness, and their surface has again ripples or little wavelets on each of the large waves which gives the character or *timbre*, so you see we can produce, by means of a vibratory style on a revolving surface, all the waves corresponding to the original sounds. It is now only necessary to again rotate the cylinder, and we can in turn cause a stylus to follow the undulations just produced, and we shall then set up in the reproducing diaphragm vibrations which shall correspond to the original vibrations as to their number, amplitude, and character. This, then, is the secret of the conditions necessary for recording and reproducing sound, irrespective of whether it be a simple tone, the human voice, or the most complex harmonies.

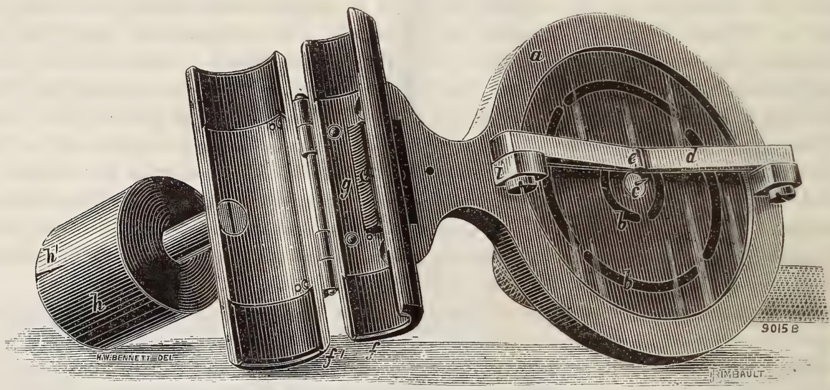
In the graphophone every mechanical detail has been carefully considered. Any machine to be popular must be simple; all superfluous details and adjustments must be avoided. The graphophone is constructed for use in the house and in the office, among the thousands of people who would possess an instrument which can be worked without skilled attention or previous knowledge of the subject, and in attaining these ends great ingenuity has been shown; and we will now proceed to examine in detail the various parts of the instrument and their relation to the whole.

We may compare the graphophone to a small lathe, in which it is proposed to revolve a cylinder and cut a screw thereon. Now, screw-cutting is an operation requiring some skill, and especially where a great number of threads to the inch are wanted, all of the same normal pitch; it is also essential that these screws when cut shall be interchangeable with any others. This instrument cuts 160 threads to the inch, the threads being only 3-1000ths of an inch in width, and 1-1000th in depth. To cut in an ordinary lathe such a thread clear and distinct would be considered a skilful operation. The lathe would have to be run very carefully, and the tool rigidly held and delicately adjusted, and the cylinder carefully centred and turned true before the screw was cut. In the graphophone all these precautions and adjustments are not necessary. The cylinder, made of two spirals of paper cemented together, is coated with a thin layer of waxy compound, and then smoothed by passing through a hot die. This gives us a light, hollow, true cylinder to start with, only requiring sufficient wax to receive the sound record, and inexpensive withal. It is now placed between these conical centres, which at one and the same time both hold it and revolve it truly, and allow it to be instantly inserted or removed. Now, for cutting the thread, the cylinder is geared by small wheels to a screw which shall cause the cutting tool in the re-

cording diaphragm to traverse the cylinder at the proper rate. This screw is ingeniously protected by a slit metal tube, which also acts as the carrying support of the recorder.

We now come to the recorder. This consists of a metal frame, carrying a diaphragm of mica or talc, which holds in its centre a small graving-tool or style, which has to cut the thread in the cylinder. A small steel bridge crosses the diaphragm frame, which has a double duty. It maintains the position of the graving-tool to cut its proper depth, and also burnishes the wax, previous to the thread being cut; also it enables the recording style, with its carriage or frame, to ride up and down in event of irregularities or eccentricity of the cylinders, and yet maintain always its relative position for proper cutting. The movement of the recorder is effected by a section of a steel nut engaging by spring con-

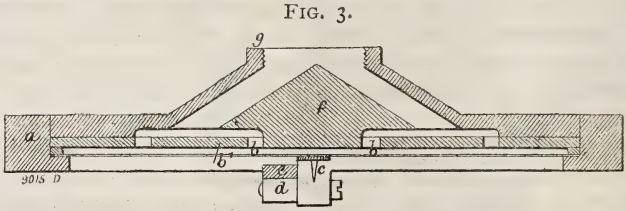
Fig. 2.



The Recorder.

tact with the revolving carrier screw traversing the cylinder to cut the thread. A counterpoise prevents the whole bearing down too heavily on the cylinder. In the act of recording, it is desirable to get the maximum amount of movement on the recording graver. A diaphragm when vibrated tends to neutralise the movement in the centre through interference, and there are nodal points where the movement is hardly perceptible. Mr. Tainter, by a deflecting cone and slotted plate, causes the sound waves to strike the diaphragm at

Fig. 3.



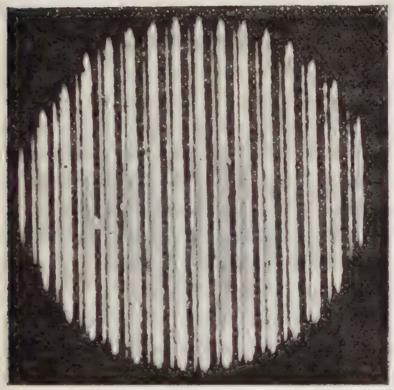
Section of Recorder.

these points, and this increases the movement and force at the centre where the graving point is. A flexible tube and mouthpiece convey the sounds from the operator to the diaphragm.

Now let us see why this not only cuts a thread, but produces a permanent sound record. When we speak to the diaphragm, it is set in motion, and vibrates in correspondence to the sounds uttered. We have now obtained our sound record, which to the eye seems simply a series of almost imperceptible dots. A question often asked me is, "How can this thing speak, and where is the music contained?" And observers sometimes, after looking into and all over the simple tube, turn away and wisely whisper, "Ventriloquism," thus paying me indirectly a compliment that Valentine Vox might have been proud of. But to reproduce the sound seems as simple, when we know the secret, as recording it. All that is necessary is to vibrate a

diaphragm with similar vibrations to the original, and it will give back similar sounds. But in order to do this, we must have motion, for, as before remarked, there can be no sound without motion. Familiar examples of this occur to all of us. It is not the iron railings and the innocent stick that offend, but the small boy who gives motion to the stick as he runs with it against the rails that makes a hideous noise. On a hot day, as long as the blue-bottle fly keeps still we do not mind his presence, but when he gets into motion we wish him somewhere else. The wind, too, has to blow, and stir into motion the strings of the Eolian harp before we can be charmed with its music. And so in this instrument we must have motion in order to produce the sounds sought for; and

FIG 4.



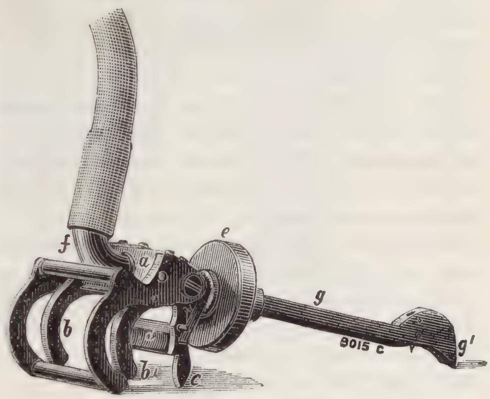
SOUND RECORD.

in order to get back the exact pitch and tone in reproducing, we must have the same rate of speed we had in recording. This brings us to our speed governor and motive power. Here, again, Mr. Tainter has shown great ingenuity. After trying all kinds of motors, such as springs, electricity, water, and compressed air, he found that for universal application he must provide a means of rotation common to all, viz., to turn it either by hand or by foot, for all the other motors mean additional parts and cost, requiring attention more or less, and costing something to operate them. Electricity, while the simplest and best of these, is not always available, and occasionally batteries break down when most wanted; therefore he adopted the treadle. This leaves the hands free, and very little fatigue is experienced in using it, the power being much less than that required by a sewing machine. But how can the irregular motion of the foot be converted into the absolutely steady motion required to rotate the cylinder?

This brings us to the speed-governor, which consists of a frame with a spindle carrying two pulleys—one driven by a small belt from below, from the fly-wheel and treadle, and the other by a belt communicating motion to the spindle carrying the cylinder in the graphophone. The two pulleys, however, are connected together by friction discs, which, by means of a spring, are kept in close contact until the velocity of the parts causes two weighted cylinders connected by levers to counteract the spring pressure, thus lessening the friction, and causing the driven pulley only to receive such motion and no more than it is adjusted for by the springs required to give the necessary velocity to the instrument.

We will now turn to the reproducer. This contains the diaphragm which must receive

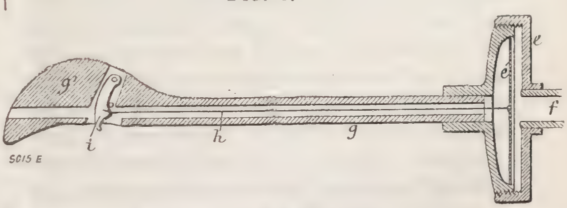
FIG. 5.



THE REPRODUCER.

the vibrations for the record in order to convey them to the ears. The record on the cylinders is most minute, the grooves are only 3-1000ths

FIG. 6.



SECTION OF REPRODUCER.

of an inch wide, and 160 of them to the inch, and we must be able to cause a stylus to follow in the groove exactly, and be in touch

with each and every undulation. Here, again, turning to the comparison of the lathe, we know how difficult it is in a rigid machine to place a cut screw, and cause a tool to exactly fit the grooves of that screw, without making a cross thread, or damaging the tool. But in the graphophone we have a cut thread in delicate wax; any displacement of the stylus would irreparably damage the record, and yet we are proposing to let such an operation be performed always, and at once, by the veriest tyro who sits down to this instrument, and this is how it is done. In the first place, instead of the several parts being rigid in their relation to each other, they are extremely flexible. The style which is to fall into the groove is a mere feather of steel, only half the width of the groove it has to fall into. It is held on a pivot in an ebonite tube, connected to a diaphragm at the other end of the tube by means of a waxed silk thread. In fact, we have here a simple mechanical telephone. The tube with this style and diaphragm is held on a slight metal frame carrying a nut, which, as in the recorder, engages with the traversing screw, so that when the cylinder is rotated the frame carrying the reproducer travels at the proportionate speed, allowing the small steel feather to ride in the groove, and by gravity rest on its point at the bottom of the groove, where it rides and vibrates according to the sound record it travels over, thereby vibrating through the silk cord the diaphragm, which in turn communicates these vibrations to the air in the tubes to each ear, where the auditory nerve translates them as sounds to the brain. And this is why the instrument talks.

Other details in the machine enable us to stop and start it instantly, so that we can take off a word at a time for purposes of writing out from dictation and repeating, going over any portion of the record we wish to re-call. And now comes the question in the minds of many in an audience like this, where we have to deal with applied science—What is the practical use of the instrument, and what will its influence be in the future? I think we may say that its possibilities are infinite. In the beautiful instrument shown you here last week, Colonel Gouraud demonstrated how music of the most complex kind could be received by the delicate diaphragm of the phonograph, and be engraved with absolute accuracy on the wax cylinder, so that when the delicately adjusted reproducer passed over the record you were charmed with the sounds that it gave out, not merely to the ear of the individual, but loudly, so that each one in this room could hear, the proportions and adjustments having been worked out by Mr. Edison in such a way that you had there a loud-speaking machine. The one we have here is not loud-speaking. It is not intended to be so. Its use is for the purpose of dictation and correspondence, and I feel some difficulty in showing you the marvels of this machine, because the dimensions are not such as to admit of its speaking loudly, so that you can hear it all together; but we have arranged for several instruments which you can hear afterwards, which will repeat to you words spoken into them in America and elsewhere. By hearing these you will be able to appreciate several uses of the instrument. The short-hand writer, for instance, can read his notes to the machine, which will then dictate them at leisure to the type-writer operator, thereby solving one of the reporter's difficulties, for the more rapidly he can report, the more difficult it is as rule for any one but himself to read his notes. Here, however, he has simply to take them to the graphophone, and dictate them, twice as rapidly, if need be, as even he has originally reported them.

Since this instrument was brought before public notice at Bath, I have been much interested to note the enormous diversity of uses that have been suggested for it. Physicians ask for it in order that, when returning home late at night, they, without any fatigue, may simply speak into the machine as to the condition of the patient visited, and suggest the necessary treatment. It is also suggested that residents in Bournemouth or Nice need not come to London to consult their own medical men, but can send samples of their cough by graphophone, thus indicating the improvement or condition of their lungs.

Blind people may also, through the medium of their ears, avail themselves of avenues of instruction and amusement to which their eyes have been so long closed.

Children who can neither write themselves, nor read the writing of others, can by this means communicate in their own childish prattle to those at a distance, who may wish to know exactly what they think.

The small tradesman who cannot afford to have his own book-keeper, and has not time during the press of business to put down the verbal orders he receives, or the sales he is making, can incidentally speak to this instrument, recording each transaction, and lei-

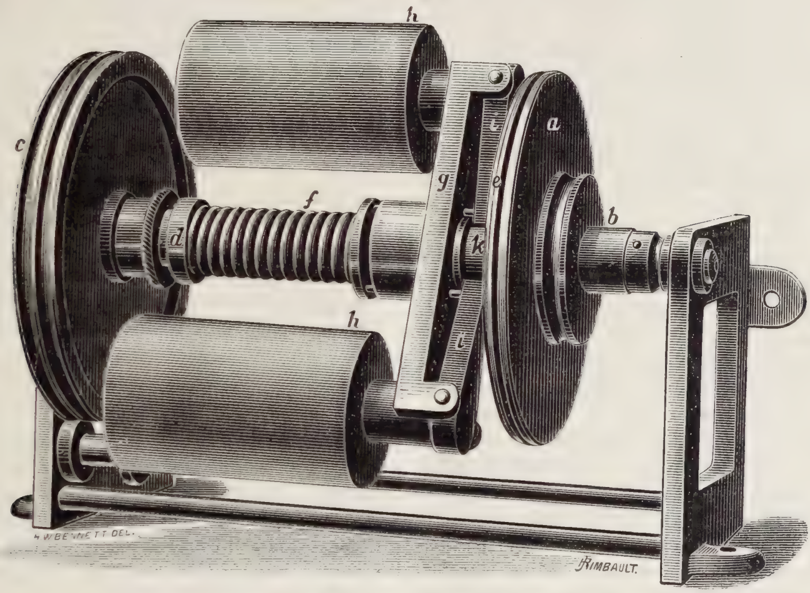
surely take off the words thus spoken, later in the day, entering them into book form.

In the office again, we, who have shorthand writers, know that many times when the writer is at liberty we are engaged, and when we are at liberty, he has gone to lunch. The machine is never out. It is always ready.

Connected to the telephone, the other day I was enabled to record the words spoken, and to re-call afterwards that which I had forgotten in the hurry of the moment, viz., whether I had made an appointment to meet a friend at London-bridge at six minutes past five, or five minutes past six. I knew it was one of the two, but it was only by this means that I could decide which.

For the purpose of transmission through the post, each detail has been carefully worked out and simplified. We have the small wooden boxes with reversible lids, one side containing the address of the sender and the other of the receiver, so that this little box may pass to and fro like a shuttle, carrying its reel of words helping to weave closer in thought and spirit those who live apart, for nothing is more conducive to the cementation of friendships, and the prevention of misunderstandings, than to communicate frequently, and hear each spoken word.

Fig. 7.



The Speed Governor.

DISCUSSION.

The Chairman said he did not propose to invite discussion on this extremely interesting paper, because the audience would probably prefer to hear the instruments which were exhibited in the lower room, but if any particular person had anything special to say, the meeting would be glad to hear it.

Colonel Gouraud said he was afraid he came within the category of "any particular person who had something to say," and with this opening remark he was afraid he should disappoint some of his hearers in what was to follow. He rose with somewhat mingled feelings; the principal feeling, however, which he had experienced was one of self-congratulation that he preceded Mr. Edmunds rather than followed him. He had thought he had some advantage in speaking a week before Mr. Edmunds, but he now found that was not so. He had to express his thanks to the reader of the paper for having given him a very interesting evening, and in saying this, he felt that he was expressing what must be on the minds of everyone present, the appreciation of not only the interesting matter which had been presented, but the admirable clearness with which it had been presented, and more than that, the excellent taste which had characterised it. In making that observation, he felt he should be understood by everybody in the way he wished to be. There was another feeling which he should like to give expression to, which was some disappointment with the audi-

ence, for he observed very much more applause when Mr. Edmunds referred to a philosopher of some previous century, who was evidently well-known to the audience, judging from the applause when the name was mentioned, than when the names of contemporary philosophers were alluded to, the audience evidently forgetting that the works of these men redounded to the glory of their own generation. Mr. Edmunds had left a great deal unsaid bearing upon the analogy between the phonograph and the graphophone, quite rightly assuming that the audience were acquainted with this aspect of the case. There was one word used by Mr. Edmunds which he was sure he would not wish misunderstood, and that was the word "perfect" as applied to the graphophone. It was very far from perfect, and he would say, if they pleased, the same even with regard to the phonograph which was called the "perfected" phonograph. Perfection with regard to the phonograph would always be only a relative term, and he said that in confidence, knowing what had been done to improve it, even since he had shown it at Bath, and the still further improvement it was undergoing in the hands of its incomparable master. That one was more perfect than the other it was safe to assume, because no two things were exactly equal. Which was the more perfect it was not for him or for Mr. Edmunds to say in that place. There were, at present, three parties to that interesting question — the phonograph, the graphophone, and the public; there might be other parties later on, and for his part he welcomed them all. He and those whom he represented did not want the whole of anything; he only wanted for Mr. Edison that share which was his due, and that the public would be sure to give him. He would conclude by saying a word to guide the public in deciding what would be perfection in a phonograph, or any speaking machine, for all practical purposes, and that was all they need trouble about. The instrument which they should look for must be one that would never fail under any circumstances whatever; no matter how badly spoken to, no matter what language spoken, nor how old or how young the speaker. It must take in what was said in front of it, keep it until it was wanted, and then give it back exactly as it had been given to it. If it did not do that, it was not only not perfect, but was worse than useless, because it was untrustworthy. The test to be applied to any speaking instrument should be not "Good morning; how do you do?" or any like commonplace expressions, such as naturally come into one's mind when asked to say something into a mixture of wood, iron, and steel, but something which had no suggestiveness about it, in which one word would not assist the hearer to the next. A sentence read backwards, a column of a newspaper read from the bottom upwards by one person, and then repeated by the machine to another person who had not heard it would be a good test. Such an instrument would "fill the bill;" it would do all that could be expected of it, and that would be the instrument the public would take. The phonograph would do this. With these observations, in which he trusted he had not violated any of the rules of good taste and fair play of which he had been set so good an example, he desired to thank Mr. Edmunds for giving them such a very pleasant evening. He should have liked to have the phonograph side by side with the graphophone that evening, and had suggested it to Mr. Edmunds, but he did not seem to think it desirable, which was perhaps not surprising, seeing that Mr. Edmunds was the *impresario* of the Volta troupe, and he (Colonel Gouraud) was the *impresario* of another one.

Mr. LASCELLES SCOTT thought, from what he had heard, that the graphophone was a rather more delicate and accurate instrument than the phonograph, and suggested that if it were capable of reproducing delicate musical sounds, it would be very valuable in teaching singing to pupils who did not possess a naturally good ear.

The CHAIRMAN said he thought they had learned one lesson that evening, and that was to say little and say it well. For fear, therefore, that he might say something which might be recorded against him perhaps 2,000 years hence, he would at once put the motion of a cordial vote of thanks to Mr. Edmunds.

The vote of thanks having been carried unanimously,

Mr. EDMUNDS, in reply, thanked Colonel Gouraud for his kind expressions. If he had accidentally said that the machine was perfect he did not wish to repeat it, for he did not think anything was perfect. Colonel Gouraud could speak splendidly for his instrument, but his (Mr. Edmunds) being a speaking machine, must speak for itself.

The SECRETARY announced that five instruments had been placed in the library for members to examine, and that they would remain there until Saturday next.

Correspondence.

DELAGOA BAY.

Delagoa Bay is situated 300 miles north of Natal, the journey being accomplished in a day and a half, in very comfortable coasting steamers. On entering Delagoa Bay the island of Inyack is rounded, presenting to the traveller a large area of low, uninteresting country, which is governed by a Queen Mapota, and is some thirty miles distant from Lorenço Marquis.

The Portuguese have a small military establishment on the island, consisting of thirty men, under a commandant. It was the intention of the Portuguese authorities to erect a lighthouse on the northern corner of the island two years ago, an improvement greatly needed.

On entering Delagoa Bay the town of Lorenço Marquis, lying on the right bank, presents a very picturesque appearance from the anchorage, it being opposite the principal square, with a background formed by a gently rising hill, over which the town must eventually be built.

Half way up the hill stand the Roman Catholic church, military hospital, and numerous small buildings, while away to the right stand the offices of the Eastern and South African Telegraph Company, overlooking the entrance to the harbour. Landing is effected by a substantial wooden pier, which, when lengthened, will enable vessels to discharge cargo alongside.

At the end of the pier there have been recently erected the new Government buildings, including court and custom-house. On the opposite corner of the square is the fort, an unpretentious-looking building, sadly in want of modern improvements and munitions of war. Proceeding up the square, into the main thoroughfare, on the left corner is the Governor's palace. Facing the square and anchorage are the offices of the several shipping companies now plying to Delagoa Bay.

Good hotels are among the many improvements yet to come with the advance of civilisation. The site on which Lorenço Marquis stands, is naturally adapted to every commercial enterprise, and with the coming prosperity to the whole of that part of the world, all the modern improvements of science are bound to follow. The streets, which are both narrow and sandy, require to be properly laid, paved, widened, and lighted, together with the most complete system of sewage, from end to end of the town.

The water supply must also claim the early attention of the authorities, as the present supply is both inadequate and inconvenient, it being supplied to the houses in tubs, suspended from poles, carried by the natives, a system which leaves much to be desired by way of improvement.

There used to be a deal of unhealthy marsh land between the town and the higher ground behind, but that has of late years been drained, thereby considerably adding to the health of the whole locality. Large portions of it are utilised for gardens, in which the sweet potato, bananas, tomatoes, and most, if not all, of the European vegetables grow prolifically.

The authorities at Port Natal have been for years spending thousands upon thousands of pounds in trying to make their port artificially, what Delagoa Bay is naturally, viz., "one of the finest natural harbours in the world," and which must become, from its geographical position, and splendid anchorage, the first port of the whole of the east and south-east coast of Africa.

It may not be generally known that goods can be landed in Delagoa Bay, taken overland, and actually sold cheaper in Natal than goods imported through Durban, the heavy dues and import duty being so excessive to meet the demands for the new harbour works and breakwater.

When the Trans-African railway is completed, and added to the already great resources of Delagoa Bay, the advantages that must accrue to the whole of those vast countries north of the Vaal river are, in their immensity, almoset unthought of.

It should not be overlooked that there is a great fishing industry to develop in and around Delagoa Bay. The prawns caught in the bay will rank amongst the finest in the world.

In addition to the great advantages of harbour and railway, it may be remembered that the latter will run through the immense coal-fields, which extend for hundreds of miles. Delagoa Bay is the most direct and shortest route to the gold-fields, but accommodation is bad on the road, there being, I believe, only two or three stores on the way, thereby earning for this route a bad reputation; but all this will cease to be when once the railway is opened for traffic.

Lorenço Marquis likewise shared a bad name for fever, &c. (which it might have deserved once, but certainly does not now). In the hot season a light fever is still prevalent, but during the two last there was not a single death to record from it, an improved state of affairs that much recommends itself to intending travellers to the gold-fields *viâ* that route.

Many Dutch Boers with their waggons now go to Lorenço Marquis trading, their outspan being on the square, in front of the anchorage, and, with a view to encouraging them, the authorities have greatly improved the road leading to the Transvaal. Lorenço Marquis, with a considerable outlay devoted to the improvements already enumerated, would bid fair to become one of the most populous and popular towns in Africa, and a port of great commercial and strategetic importance. Then a country, town, and harbour, possessing all the richest gifts of nature, and once almost forgotten and deserted, will rise to fame and wealth, and open up an emporium of vast importance to the whole of the commercial world, and prove itself, in the very near future, to be one of the richest jewels in the crown of Dom Luis of Portugal.

Paul Mapp, F.R.G.S.

The following is a chronology of the chief events connected with Delagoa Bay:—

A.D. 800.—Rio-de-la-Goa, known to the Arabs by the name of Dugutha.

December 24th, 1688.—An expedition, by land, under Isaac Schyver, ordered to proceed to the Rio-de-la-Goa to explore the country.

December 10th, 1720.—An expedition directed to

proceed to Rio-de-la-Goa and Natal, and there form settlements.

July and September, 1723.—Report received that the establishment at Rio-de-la-Goa was in a bad state, and robbed by pirates. Orders given to strengthen fort.

May 22nd, 1724.—Orders issued to examine minerals at Rio-de-la-Goa.

1726.—The establishment at Rio-de-la-Goa amounted to 200 souls. Great anxiety to conceal from the English the real state of Rio-de-la-Goa. Sample of oil sent to Europe.

1727.—Experiments on gold dust from Rio-de-la-Goa found to be sand.

1729.—Orders received from Europe to abandon Rio-de-la-Goa, but to examine previously where two parcels of gold dust were obtained. Thirty Europeans massacred there.

June 11th, 1730.—Establishment at Rio-de-la-Goa finally abandoned.

1756.—Trade continued to be carried on with Rio-de-la-Goa, and 5,800 lbs. of ivory exported from there.

MEETINGS OF THE SOCIETY.

ORDINARY MEETING.

DECEMBER 12.—"Explosives." By W. H. DEERING, F.C.S. SIR FREDERICK ABEL, C.B., D.C.L., F.R.S., President of the Government Commission on Explosives, will preside.

DECEMBER 19.—"Standards of Light." By W. J. DIBDIN, F.I.C., F.C.S.

FOREIGN AND COLONIAL SECTION.

The meetings of this Section will take place on the following Tuesday evenings, at Eight o'clock:—

January 29; February 19; March 12; April 2, 30; May 21.

INDIAN SECTION.

The meetings of this Section will take place on the following Friday evenings, at Eight o'clock:—

January 25; February 15; March 8, 29; May 3, 24.

APPLIED ART SECTION.

The meetings of this Section will take place on the following Tuesday evenings, at Eight o'clock:—

January 22; February 5, 26; March 19; April 9; May 14.

CANTOR LECTURES.

The following courses of Cantor Lectures will be delivered on Monday evenings at Eight o'clock:—

Captain W. DE W. ABNEY, C.B., F.R.S., "Light and Colour." Four Lectures.

LECTURE III.—DECEMBER 10.—Mixtures of colours.—Impure colours.—Effect of ground in water colours.—The measurement of colour in terms of a standard.—The reproduction of the colours of a pigment.

JUVENILE LECTURES.

Two Juvenile Lectures, entitled "How Chemists Work—an example to Boys and Girls," by HENRY E. ARMSTRONG, Ph.D., F.R.S., will be given on Wednesday evenings, January 2 and 9, 1889, at Seven o'clock.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, DEC. 10...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Captain W. de W. Abney, "Light and Colour." (Lecture III.)

Surveyors, 12, Great George-street, S.W., 8 p.m.

Geographical, University of London, Burlington-gardens, W., 8½ p.m.

Medical, 11, Chandos-street, W., 8½ p.m.

London Institution, Finsbury-circus, E.C., 5 p.m. Prof. Silvanus Thompson, "The Colours of Polarized Light." (Lecture II.)

TUESDAY, DEC. 11...Medical and Chirurgical, 53, Berners-street, Oxford-street, W., 8½ p.m.

Civil Engineers, 25, Great George-street, S.W., 8 p.m. Discussion on Mr. Arnold's paper, "The Influence of Chemical Composition on the Strength of Bessemer Steel Tires."

Anthropological, 3, Hanover-square, W., 8½ p.m. 1. Dr. J. G. Garson, "Exhibtion of a new form of Anthropometric Instrument, specially designed for the use of travellers.." 2. Rev. R. H. Codrington, "Social Regulations in Melanesia." 3. Mr. A. W. Howitt, "Australian Message Sticks and Messengers."

Colonial Institute, Whitehall-rooms, Hôtel Métropole, Whitehall-place, S.W., 8 p.m. Mr. William Gisborne, "Colonisation."

WEDNESDAY, DEC. 12...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. W. H. Deering, "Explosives."

Graphic, University College, W.C., 8 p.m.

Microscopical, King's College, W.C., 8 p.m. 1. Mr. J. Rattray, "Revision of the genus *Auliscus* Ehrb." 2. Dr. F. H. Bowman, "Notes on the Frustule of *Sarirella gemma*."

Entomological, 11, Chandos-street, W., 7 p.m.

THURSDAY, DEC. 13....Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

London Institution, Finsbury-circus, E.C., 6 p.m. Prof. C. Stewart, "Life History of Some Plants."

Telegraph Engineers and Electricians, 25, Great George-street, S.W., 8 p.m. 1. Annual General Meeting. 2. Discussion on Mr. Henry Edmunds paper, "A System of Electrical Distribution."

Mathematical, 22, Albemarle-street, W., 8 p.m.

FRIDAY, DEC. 14...Civil Engineers, 25, Great George-street, S.W., 7½ p.m. (Students' Meeting.) Mr. Julian King-Salter, "The 26-knot Spanish Torpedo-Boat, *Ariéte*."

Astronomical, Burlington-house, W., 8 p.m.

Quekett Microscopical Club, University College, W.C., 8 p.m.

Clinical, Berners-street, W., 8½ p.m.

Journal of the Society of Arts.

No. 1,882. Vol. XXXVI.

FRIDAY, DECEMBER 14, 1888.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

JUVENILE LECTURES.

The usual short course of lectures adapted for a juvenile audience, will be given on Wednesday evenings, January 2 and 9, 1889, by Dr. H. E. Armstrong, F.R.S., on "How Chemists Work—an example to Boys and Girls."

The lectures will commence at seven o'clock. A sufficient number of tickets to fill the room will be issued to members in the order in which applications are received, and the issue will then be discontinued. Subject to these conditions, each member is entitled to a ticket admitting two children and an adult. Tickets are now in course of distribution, and members requiring them should apply at once.

CANTOR LECTURES.

Captain W. de W. Abney, C.B., F.R.S., delivered the first three lectures of his course of Cantor lectures on "Light and Colour" on Monday evenings, November 26, December 3 and 10 respectively. The fourth and last lecture will be delivered on the 17th inst.

The lectures will be printed in the *Journal* during the Christmas recess.

APPLIED ART SECTION.

A meeting of the Committee of the Section of Applied Art was held on Friday, 7th inst., at 4 p.m. Present: — Sir George Birdwood, K.C.I.E., C.S.I., LL.D., M.D., in the chair, Mr. T. Armstrong, Prof. A. H. Church, Mr. B. Francis Cobb, Mr. I. Hunter Donaldson, Major-General Donnelly, C.B., Mr. J. Starkie Gardner, Dr. Salviati, Mr. W. H. James Weale, with Mr. H. Trueman Wood, Secretary of the Society, and Mr. H. B. Wheatley, Secretary of the Section. The programme of papers to be read during the present Session was discussed.

COVERS FOR JOURNAL.

For the convenience of members wishing to bind their volumes of the *Journal*, cloth covers will be supplied post free for 1s. 6d. each, on application to the Secretary.

LIST OF MEMBERS.

The new edition of the List of Members of the Society is now ready, and can be obtained by members on application to the Secretary.

Proceedings of the Society.

FOURTH ORDINARY MEETING.

Wednesday, December 12th, 1888; Sir Frederick Abel, C.B., D.Sc., D.C.L., F.R.S., President of the Government Commission on Explosives, in the chair.

The following candidates were proposed for election as members of the Society:—

Boulnois, Henry Percy, Municipal Offices, Portsmouth.
Gillespie, Edward James, 16, Mincing-lane, E.C.
Grundy, James, 343, Derby-street, Bolton, Lancashire.
Hutt, C. F. Ormond, 28, Hungerford-road, Holloway, N.
Jeans, J. Stephen, Victoria-mansions, Victoria-street, S.W.
Middlehurst, John Edward, Springwood, Swinton-park, Lancashire.
Morley, John G., Heathlands, Chadwell-heath, Essex.
Pankhurst, Richard Marsden, LL.D., 10, St. James's-square, Manchester.
Tadman, Edward Thomas, Cromer-lodge, West Hampstead, N.W.

The following candidates were balloted for and duly elected members of the Society:—

Carter, Joseph Robert, 14, King's Arms-yard, E.C., and 2, Steele's-road, N.W.
Day, Richard Evan, 48, Belsize-square, Hampstead, N.W.

Dowis, Philip H., 171, Queen Victoria-street, E.C., and 106, Salcott-road, S.W.

Jones, Henry Arthur, Townshend-house, North-gate, Regent's-park, N.W.

AND AS AN HONORARY CORRESPONDING MEMBER.

Berger, Georges, 8 Rue Legendre, Paris.

The paper read was—

EXPLOSIVES.

By W. H. Deering, F.C.S., F.I.C.

The last paper on explosives read before the Society was that by Mr. Alfred Nobel, in 1875, and I have taken as the most useful subject for the present paper the mention of some of the more important of the explosives, or of the methods of treatment, introduced in the long interval.

Gunpowder.

In the case of gunpowder, there has been the important innovation of brown or cocoa powder, introduced in Germany in 1882. Previously to that date the gunpowders in military use were black, and had the following composition (the moisture always present being deducted):—

	Nitre. Potass. Nitrate.	Sulphur.	Charcoal.
England	75	10	15
France (cannon powder)	75	12·5	12·5
Germany	74	10	16
Austria	75·5	10	14·5

The brown powder, however, has the composition of 79 per cent. potassium nitrate, 3 per cent. sulphur, and 18 per cent. charcoal. This is the composition given in Mr. J. N. Heidemann's patent (Eng. Pat., Dec. 11th, 1884, No. 16314), where it is further stated that the brown carbonaceous substance used as charcoal is obtained by carbonising straw until it attains a brown chocolate-coloured appearance, when it is cooled, powdered, and mixed with the nitre and sulphur in the proportions mentioned.

Used in the prismatic form, the brown powder (for equal velocities imparted to the projectile) produces considerably less pressure, and less smoke, than black prismatic powder of the old composition.

Captain A. Noble and Sir Frederick Abel, in their researches on fired gunpowder, found the quantity of heat evolved, and the volume in cubic centimetres of permanent gases (*i.e.*, the water being condensed to liquid) at 0° C, and 760 mm. pressure, per one gramme of dry powder, to be:—

	Cocoa prism.	Black pebble.
Units of heat evolved (gramme-degrees Centigrade)	837	721
Volume of permanent gases (cubic centimetres)..........	198	278

The cocoa powder, then, gives on explosion a greater quantity of heat, but a less volume of permanent gases, than the black powder. The larger quantity of water-vapour produced in the case of the brown powder would, from its high specific heat, also have some influence in lowering temperature, and, consequently pressure; but the lower pressures produced in the gun with brown powder must be largely attributable to a slower rate of combustion.

Brown powder contains more nitre and less reducing matter than black powder; and the saline residue produced by its explosion is completely oxidised, and consists of potassium carbonate and sulphate, and no sulphide; and the gases of explosion contain a much smaller proportion of incompletely oxidised constituents than in the case of black powder. The latter gives, when exploded, a considerable quantity of potassium sulphide. I shall be able to show this difference in chemical composition of the residue by inflaming, in these plates, an equal weight of black and brown powder; much potassium salt goes off in the powder-smoke, but we will dissolve the residues in a little water, filter, and add to the filtrates lead acetate solution and acetic acid, when we shall obtain black lead sulphide from the black powder, and only white or slightly grey lead sulphate from the brown powder.

Amide Powder.—An explosive preparation for use in guns, or as a blasting powder, was patented recently in this country by F. Gaens (Eng. Pat., year 1885, 24th Nov., No. 14412). The specification contains some points of interest; the patentee proposes "to replace sulphur by an ammonium salt, in combination with saltpetre in such proportions that on ignition potassamide is formed, a compound which is volatile at high temperatures, and which increases the useful effect of the explosive, and burns without residue." In the case of ammonium nitrate, he gives as the fundamental equation:—

$$KNO_3 + H_4N.\ \ NO_3 + 3C = KH_2N + H_2O + CO + 2CO_2 + 2N.$$

according to which the amided power would consist of 101 parts by weight of potassium

nitrate, 80 parts of ammonium nitrate, and 40 parts of charcoal; and the explosive prepared in such proportions is stated by the patentee to leave very little, if any, residue when burned, to produce no gases injurious to the gun, and much less smoke than ordinary gunpowder. He states that other ammonium salts than the nitrate may be used, keeping to such proportions as to produce amide on explosion of the mixture.

I have not, however, been able to find in chemical literature the volatility of a potassamide recorded. We have to go back to the time of Gay-Lussac and Thénard, and of Davy, for what information we have on the subject. They describe a monopotassamide KH_2N, and a tripotassamide or nitride of potassium, K_3N, the latter formed by heating monopotassamide to redness in a closed vessel, $3KH_2N = K_3N + 2NH_3$. Davy says that it (the tripotassamide, K_3N) separates at a very high temperature into potassium and nitrogen gas.

Probably the valuable properties of such a powder as that proposed in this interesting specification could be explained on other grounds.

In respect to the use of ammonium nitrate in gunpowder, but not in the same direction as in the patent just referred to, I may mention that Dr. H. Sprengel, in 1873, observed that an increased initial velocity was imparted to a rifle bullet, when a mixture of ammonium nitrate and charcoal was substituted for a portion of the gunpowder charge (Dr. Sprengel used sporting-powder—"Journal Chemical Society," 1873, p. 805); and that the powder used in 1887, in the cartridge of the Swiss 7·5 mm. Hebler rifle had $\frac{4}{5}$ths of the usual potassium nitrate replaced by ammonium nitrate ("Mittheilungen über Gegenstände des Artillarie und Genie-Wesens," year 1888, p. 289).

Gun-cotton.

Since Sir Frederick Abel's method of treating gun-cotton, by reducing it to pulp, thoroughly washing and mixing it in water by a paddle-wheel, and subsequently strongly compressing the pulp into cylinders, slabs, &c., by hydraulic pressure, comparatively little has been done in the manufacture and treatment of gun-cotton. Von Förster and Wolff, in 1883, patented the treatment of moist or dry gun-cotton by immersion in a solvent, such as acetic ether, or nitrobenzene. When a piece of compressed gun-cotton is immersed for about half a minute in acetic ether, then exposed to the air to allow the solvent to evaporate, it becomes coated with a thin but hard skin of dry gun-cotton. Von Förster purposed applying this to moist and to dry compressed gun-cotton, to retain the water in the former case, and to exclude it in the latter, by a waterproof coating formed by gelatinising the gun-cotton by acetic ether. This coating was, however, found to have minute cracks in it, so that he subsequently coated his dry gun-cotton primers externally with paraffin, the hole for the detonator alone being gelatinised by acetic ether (so as not to diminish its sensitiveness to detonation). In recent experiments with gun-cotton shells in Germany and Italy, those forms of shell which had to be charged through their fuze-hole were filled with log-shaped pieces of moist gun-cotton (about 1 to 2 inches long, with sides of 0·4 in. to 0·7 in.) sawn from wet compressed slabs, and which had been coated by dipping into acetic ether; the chamber of the shell was then filled with a mixture of equal weights of paraffin and carnauba wax, melted, and at a temperature of about 180° Fah., poured in through the fuze-hole.

Nitroglycerin.

In the preparation of nitroglycerin explosives, much has been done since 1875. The most noteworthy invention in this important group of explosives has been Mr. Nobel's *Blasting Gelatin*, introduced, I believe, in 1879. This well-known explosive is composed of about 93 parts by weight of nitroglycerin and 7 parts of nitro-cotton; the latter is less highly nitrated than gun-cotton. The nitro-cotton is dissolved in the nitroglycerin contained in a copper vessel, and maintained at a temperature of 95° Fah. by means of warm water. The mixture is kept mechanically stirred during the heating; the nitro-cotton dissolves, and a mass of the consistence of thin dough is obtained, which stiffens on cooling.

Here is a cartridge of blasting gelatin of Ardeer make; it is a brownish yellow, semi-transparent, gelatinous substance. Its specific gravity is but little less than that of nitroglycerin, which is 1·6. It does not break up nor part with its nitroglycerin when immersed in water, as does kieselguhr dynamite, which is a great advantage; it requires, however, a stronger detonator than thawed kieselguhr dynamite, and detonation is not propagated through a train of blasting gelatin cartridges freely exposed, as in the case of dynamite. Its power as an explosive is about half as great

again as that of kieselguhr dynamite (of 75 per cent. nitroglycerin), and where applicable there would be economy in its use, as compared with the latter explosive.

Nitroglycerin contains more oxygen (3·52 per cent.) than is required for its complete combustion to carbonic acid and water, while dinitrocellulose is deficient by 44·4 per cent. oxygen for complete combustion, so that blasting gelatin contains the amount of oxygen required for complete combustion.

A cold process for gelatinising nitroglycerin by means of collodion nitro-cotton, was patented in 1887 by the *Deutsche Sprengstoff-Actiengesellschaft* of Hamburg (D.R.P., No. 42452; Eng. Pat., No. 2318). The cold gelatinising was to be effected by dissolving picric acid (up to about 10 per cent., the quantity depending on the quantity and quality of the nitro-cotton employed, and the required consistency of the jelly) in the nitroglycerin, and adding to this solution finely-powdered or ground collodion nitro-cotton, the gelatinising being assisted by frequent stirring. Pure tetranitrocellulose (probably what is generally called dinitrocellulose, $C_6H_8(NO_2)_2O_5$, is meant) is said to dissolve in two days. The proposed process is interesting, but it is questionable whether it is in actual use.

Gelatin Dynamite was introduced comparatively recently by Mr. Nobel. The No. 1 grade consists of 65 per cent. of a thin blasting gelatin and 35 per cent. of a combustible mixture; the No. 2 grade contains 45 per cent. and 55 per cent. respectively. The gelatin consists of 97·5 per cent. of nitroglycerin and 2·5 per cent. soluble nitro-cotton; the combustible mixture of potassium nitrate 75 per cent., wood-meal 24 per cent., sodium carbonate 1 per cent. *Gelignite* is a variety composed of 60 per cent. of a thin blasting gelatin (56·5 per cent. nitroglycerin and 3·5 per cent. nitro-cotton), 32 per cent. potassium nitrate, and 8 per cent. wood-meal.

These are cartridges of gelatin dynamite and of gelignite: they are elastic gelatinous substances, and will bear immersion in water without parting with their nitroglycerin.

Experiments of Sir Frederick Abel's give the power (or intensity of action), when suitably detonated, of gelatin dynamite, No. 1 grade, of recent Ardeer make, as = 127, another experiment gave 123, mean = 125. He found the power of gelignite to be 100; kieselguhr dynamite, No. 1, of 75 per cent. nitroglycerin, from the same source being = 100.

I will digress to mention that these estimations of intensity of action were made by detonating an ounce of the explosives (or 1½ oz. in some cases) in the bore-hole of a large cylinder of soft lead. Sir Frederick Abel has used the method since 1878, employing large cylinders 12 inches high, and 12 inches in diameter, having a central cylindrical hole, 7 inches deep and 1·3 inch in diameter. A 1 oz. gun-cotton primer just fits the hole; explosives of the consistence of dynamite are compressed in it by means of a wooden rammer, cast or compressed charges are filed to fit the hole. The cylinder is made to stand on a wrought-iron plate, the explosive placed in the charge-hole, and suitably provided with a fulminate of mercury detonator, or with fulminate detonator and intermediate priming, such as may be necessary to obtain the maximum effect; the charge-hole is then filled with fine dry sand, poured in (not compressed) and around the insulated wires in the usual case of the charge being fired electrically. There is usually a column of about six inches of sand. The detonation of an explosive susceptible of it takes place with great rapidity, so that the amount of enlargement of the charge-hole (ascertained by measurement with water before and after the explosion) gives a measure of the combined effect of the pressure produced by the detonation of the explosive, and of its rate of detonation. In the case of a very inert explosive needing strong confinement, a shell would be charged with it, buried in earth, and detonated electrically, and the crater produced measured; or the shell detonated in a suitable cell, and the number and weight of the fragments noted, comparative experiments with gun-cotton or dynamite being made in in these cases, as in that of the lead cylinders.

Carbo-dynamite is an explosive, the invention of Messrs. Borland and Reid, and patented by Mr. W. D. Borland in 1886 (January 18th, No. 758), in which the nitroglycerin is absorbed by cork-charcoal. From the statements made, the cork-charcoal appears to have remarkable absorbing power. The patentee recommends the material obtained by incorporating about eight parts (by weight) of nitroglycerin with about one part (by weight) of cork-charcoal, as convenient of manipulation. It is stated that no nitroglycerin is separated from this preparation by immersion in water for several months. I have arranged here cylinders of water, in which are suspended tubes open at both ends,

containing kieselguhr dynamite, blasting gelatin, gelatin-dynamite, and carbo-dynamite, showing the retention of the nitroglycerin by the last three, and the breaking up of the first-named explosive. An account is given in *Engineering*, of April 20th, 1888, of some experiments with carbo-dynamite, from one of which—comparative detonations in lead cylinders (on a smaller scale than in the experiments referred to above), of carbo-dynamite and ordinary kieselguhr dynamite—the carbo-dynamite used (stated to contain 90 per cent. nitroglycerin) gave a result such as would have been given by blasting gelatin, which explosive it resembles in its high percentage of nitroglycerin, but from which it differs by its other constituent being non-explosive, and by its being deficient in oxygen for complete combustion into carbonic acid and water. Mr. Borland also claims that the addition of 3 per cent. cork-charcoal to kieselguhr dynamite (of 75 per cent. nitroglycerin) enables the preparation to bear immersion in water without parting with its nitroglycerin. Further, the inventor claims that by incorporating carbo-dynamite (by kneading) with one-fourth of its weight of water, a dynamite is produced which is uninflammable, but which can be exploded by a suitable detonator; also that under these circumstances the product so obtained detonates without flame, rendering it a safe explosive for use in coal mines.

Mr. Nobel's gelatinous nitroglycerin preparations are said to be replacing kieselghur dynamite. They are largely used in coal-getting in conjunction with an envelope of water, forming the "water-cartridge." The object of using an envelope of water is the suppression of flame or sparks from the explosive itself, and the prevention of the heating to incandescence of particles of the tamping employed, or from the sides of the bore-hole. This use of a water-envelope with a high explosive is due to Sir Frederick Abel; he had, in 1873, used water as the medium for conveniently transmitting and causing to act on a considerable surface, the pressure caused by the detonation of small charges of explosive, and subsequently (in 1880-81), with Mr. Smethurst, he made the extinguishing action of a water-envelope the subject of experiment in collieries near Wigan. The results obtained then, and afterwards, for the late Royal Commission on Accidents in Mines, those made by the Prussian and Saxon Commissions, and the experience obtained in collieries where a "water-cartridge" is used with gelatin-dynamite as the explosive, justify confidence in the safety given to coal-blasting by the suitable use of a water-envelope round the explosive (the volume of the water must be at least four times that of the explosive), especially when the latter is of the gelatin-dynamite type; the charge being fired electrically, or by other safe means.

E. D. Müller has patented (Eng. Pat., Sept. 13th, 1887, No. 12424) the mixing of salts containing a large amount of water of crytallisation with ordinary nitroglycerin explosives; with a kieselguhr dynamite, or a dynamite with a combustible absorbent (*e.g.*, wood-meal and a nitrate); or for hard coal and inflammable coal dust, with fire-damp also present, he uses a mixture of blasting gelatin, or gelatin-dynamite with the hydrous salts. (The nitroglycerin may be partly replaced by nitrobenzene, nitrotoluene, or nitronaphthalene.) The hydrated salts are to contain at least five molecules of water of crystallisation, and those more particularly recommended are soda crystals ($Na_2 CO_3 10 HO_2$), or sodium sulphate ($Na_2 SO_4 10 H_2O$), or for use in warm climates or warm places, magnesium sulphate ($Mg SO_4 7H_2O$), as being less liable to lose its water. These salts contain respectively 62·9 per cent., 55·9 per cent., 51·2 per cent. of water of crystallisation; they are to be mixed in the state of powder with the explosive, in such proportion that the resulting compound shall contain 15 to 65 per cent. of the hydrated salts. The mixture is made into cartridges. These preparations have received the name of "Wetterdynamit," or fire-damp dynamite, and very promising results in respect to the safety for blasting in the presence of fire-damp and coal dust, of soda-dynamite containing 40 per cent. to 45 per cent. soda crystals, have been obtained in Germany, and the subject is under experimental examination by Sir Frederick Abel.

The French Committee on Explosives have this year obtained favourable results in experiments at Sevran-Livry with mixtures of equal weights of dynamite and soda crystals, or sodium sulphate, or ammonia-alum, or of ammonium chloride, none of which when detonated in an explosive gaseous mixture caused it to explode. They state that only those explosives, the temperature of the products of detonation of which exceeds 2200° C (3992° F.), are able to cause the explosion of fire-damp. The temperature given on detonation by ordinary dynamite they state to be 2940° C. (5324° F.), by nitroglycerin

3170° C. (5738° F.), by gun-cotton 2636° C. (4777° F.). Mallard and Le Chatelier (*Comptes Rendus*, cvii, pp. 96-99) obtained good results with a mixture of 20 per cent. of dynamite, or nitroglycerin, or gun-cotton, with 80 per cent. ammonium nitrate; the ammonium nitrate lowering the temperature, that of its detonation-products being estimated at 1130° C. (2066° F.).

In concluding this part of my subject, it may be mentioned that to obtain safe explosives for coal-blasting, Kubin and Siersch have patented the mixing of 20 to 50 per cent. of ammonium chloride or sulphate, or of both, with dynamite, &c. (Eng. Pat., March 10, 1888, No. 3759); Kuhnt and Deissler, the mixing of 60 per cent. ammonium carbonate with 40 per cent. of dynamite (Eng. Pat., April 21, 1888, No. 5949); and that Schöneweg, with the same object, uses oxalic acid, or potassium, sodium, or ammonium oxalates, in an annular case external to the explosive, which may be his "*Securite*," or other explosive.

Panclastite and Hellhoffite—Panclastite was patented by Mr. E. Turpin, in 1881 (Eng. Pat., Oct. 18, 1888, No. 4544), the subject-matter of the specification being the manufacture and applications of hyponitric anhydride, or nitrogen tetroxide, N_2O_4. This was to be prepared by strongly heating lead nitrate—a method of preparation due to Gay-Lussac. When this salt is strongly heated, there is produced (as you will see) dark-brown gas, consisting of nitrogen tetroxide, and oxygen. The reaction is expressed thus:—

$$Pb(N_2O_3)_2 = PbO + N_2O_4 + O.$$

(For the sake of simplicity I speak of the gas at higher and lower temperatures as N_2O_4.) The gas was to be condensed in enamelled cast-iron condensers, maintained at freezing point. The nitrogen tetroxide solidifies at − 10° C. (+ 14° F.) (Deville and Troost), melts at − 10° to − 9° C. to a liquid, which at our ordinary room temperatures is of orange-yellow colour, boils at 22° C. (72° F.), and gives off at ordinary temperatures suffocating and irrespirable vapours.

Turpin (*loc. cit.*) proposed the preparation of an explosive, which he called *Panclastite* (of obvious etymology, from πᾶν and κλάω, *breaking everything*), by mixing carbon disulphide with nitrogen tetroxide, which are mutually soluble. He states that the maximum power is obtained from a mixture of equal quantities of the two constituents. Whether equal weights are intended, or equal volumes (when the weight relation would be 1 part by weight CS_2, and 1·14 parts by weight N_2O_4), the proportions recommended would be considerably deficient in oxygen even for the formation of carbon monoxide and sulphur dioxide, for:— $4CS_2 + 5N_2O_4 = 4CO + 8SO_2 + 10N$, and if the reaction proceeded in that way, 1 lb. carbon disulphide would require 1.51 lb. of nitrogen tetroxide; while for the higher oxidation $2CS_2 + 3N_2O_4 = 2CO_2 + 4SO_2 + 6N$, 1 lb. disulphide would require 1·82 lb. of N_2O_4. The mixture was to be detonated by fulminate of mercury, or by a charge of fine gunpowder.

I have no personal experience of this preparation, but it is stated to be a powerful explosive.

Dr. Sprengel has pointed out (*loc. cit.*) that nitric anhydride, nitrogen tetroxide, and nitric acid, head the list of oxidising compounds, containing respectively 74·1 per cent., 69·6 per cent., 63·5 per cent. of oxygen available for the oxidation of other substances. Nitric anhydride is at present, however, only a chemical curiosity, and is difficult and costly to prepare; so that of procurable compounds nitrogen tetroxide contains most available oxygen. It has the advantage also, as Berthelot has pointed out, of its formation being attended with scarcely any loss of energy; its heat of formation being for the liquid state only + 1·7 kilogramme-degree C. per 46 grammes (NO_2), while that of liquid nitric acid (from nitrogen, oxygen, and *water*) is higher, being + 7·1 kilogramme-degrees C. per HNO_3 (which becomes + 7·8 heat-units for the same quantity of available oxygen as in nitrogen tetroxide, and in addition there would be absorption of heat in gasifying the dead weight of combined water).

The use of this explosive for blasting in mines, can hardly have been contemplated, as the presence of sulphurous acid in the gases would render the air unbreathable. Mr. Turpin has also proposed as explosives mixtures of nitrogen tetroxide with benzene, petroleum, and other substances.

Dr. Sprengel, writing in 1886, states that at that time nitrogen tetroxide was a commercial article, in price about eighteenpence per lb., and that it was sent about in France in tinned cans. (*Chemical News*, Feb. 26th, 1886, p. 100.)

The use of these nitrogen tetroxide explosive mixtures appears, however, to be at present at a standstill.

Hellhoffite is one of Dr. Sprengel's nitric acid explosives, which was re-introduced by

Hellhoff, of Berlin. It consists of 1 part by weight of dinitrobenzene and 1·5 part by weight nitric acid, or of 1 part nitro-benzene and 2·5 parts nitric acid; these are the calculated proportions for complete oxidation, viz.:—

$$C_6H_4(NO_2)_2 = 6CO_2 + 2H_2O + 2N - 10O.$$

that is, dinitrobenzene is 95·24 per cent. deficient in oxygen for complete oxidation to carbon-dioxide and water, and requires 1·5 times its weight of absolute nitric acid to supply the deficiency; and, similarly, nitrobenzene $C_6H_5NO_2$ is 162·6 per cent. deficient in oxygen for complete combustion, and requires 2·56 times its weight of nitric acid. The dinitrobenzene is a crystalline solid; that most usually met with is called metadinitrobenzene, and is one of three dinitrobenzenes (it is the one obtained most abundantly on heating mononitrobenzene with mixed nitric and sulphuric acids), having the same per-centage composition but different melting points, and other differences in their properties. The dinitrobenzene dissolves readily in the nitric acid, with considerable fall of temperature; the mononitrobenzene dissolves with considerable rise of temperature. In the former case there is the absorption of heat which would attend the solution of any solid in a liquid solvent which had no chemical action upon it; in the latter case there is rise of temperature, caused by chemical action. I should have mentioned that the nitric acid used is of 1·5 specific gravity (nearly absolute nitric acid). I shall be able to show the fall and rise of temperature in the respective cases, by means of this air-thermometer arrangement, the air-bulb being immersed in the nitric acid, to which we will add the dinitrobenzene in the first experiment, and, to an equal quantity, the mononitrobenzene in the second. The contraction and the expansion of the air in the bulb are made visible by the change of level in opposite directions of the coloured indicating liquid.

Suitably primed, the dinitrobenzene nitric acid solution is a very powerful explosive. In experiments of Sir Frederick Abel's, in 1883, in which the solution mentioned was contained in a strong and closed iron vessel, which was buried in earth, and detonated electrically, effects were produced which approached (but were rather below) those produced by blasting gelatine under similar circumstances, It has been proposed for a special military use. For blasting in mines, there would be very serious inconveniences attending the use of nitrogen tetroxide or nitric acid explosive mixtures.

I have spoken of these explosives, using the names "Panclastite" and "Hellhoffite," under which they have been written about, and in connection with which you might desire information, but the invention of these explosives is due to Dr. Sprengel. Thus, in 1873, in his well-known and highly suggestive paper, "On a New Class of Explosives, &c." ("Journal Chemical Society," 1873, pp. 796-808), he covers the general principle by his statement that a variety of organic substances dissolved in nitric acid of about 1·5 specific gravity, explode by detonation. He experimented with the nitrobenzene mixture, and stated that it could be detonated with intense violence by the explosion in it of a fulminate of mercury detonator; and remarked that dinitrobenzene added to nitric acid would probably lower the temperature. He pointed out the high position of nitrogen tetroxide as an oxidiser, but as it was not then an article of commerce, turned to the use of nitric acid as the highest in value of procurable oxidisers.

Favier's Explosive, Bellite, Securite.—These three explosives may be conveniently mentioned together; they are a kind of Sprengel explosive, with ammonium nitrate taking the place of the nitric acid. A solid, non-corrosive product is thus produced. The available oxygen in ammonia nitrate is low, for here the base is combustible; the decomposition, $NH_4NO_3 = 2N + 2H_2O + O$, corresponds to an available 20 per cent. oxygen in the nitrate. Hence the quantities of ammonium nitrate have to be large, and a comparatively inert explosive (requiring a considerable amount of priming) is produced; for although Berthelot shows that the decomposition equated above is accompanied by considerable evolution of heat, yet the particles of oxidiser and fuel are comparatively far apart compared with the constituent atoms of an explosive chemical compound, or with the molecules of an explosive solution like the so-called Hellhoffite.

Favier's Explosive is of Belgian origin, patented by P. A. Favier (his French patent bears date July 21st, 1883), and is said to consist of nitrates, mixed with paraffin, resin, or preferably nitronaphthalene. He recommends the following mixtures:—100 parts by weight ammonium nitrate, 5·75 parts paraffin, or 7·12 parts resin, or 9·02 parts nitronaphthalene; or 100 parts sodium nitrate, 9·26 parts paraffin, 13·40 parts resin, or 18·93 parts nitronaphthalene. The ingredients to be mixed

and kneaded warm, and warm pressed; the cartridges to be coated with lac or resin by use of a suitable solution. It is stated that the explosive requires a priming of about 20 per cent. of dynamite, gun-cotton, or similiar substance, placed in a cavity in the pressed cartridge.

Bellite was introduced by C. Lamm, of Stockholm, and patented in this country in 1885 (Eng. Pat., Nov. 10th, 1885, No. 13690). He proposed to mix a nitrate with an aromatic nitro-compound (such as dinitrobenzene, trinitronaphthalene, or nitrotoluene), the mixing being effected in a drum heated by steam to 50° to 100° C. (122° to 212° F.), the nitro-compound melting and coating the particles of nitrate, cartridges being pressed while the mixture is warm. It may be noticed that according to recent descriptions, the three trinitronaphthalenes which have been obtained all melt above 100° C. The dinitrobenzene usually obtained (the *meta*-modification), when pure, melts at 89° C. (192° F.), the commercial article at about 86° C. (187° F.). Here is some of it; we shall see that it readily melts in a test-tube placed in nearly boiling water.

Mr. Lamm, in the specification referred to, recommended the use of mixtures of potassium nitrate with dinitrobenzene, or with trinitronaphthalene, in such proportion as to oxidise the carbon to carbon monoxide; or, if considered advisable, the amount of nitrate might be increased to the proportion required for complete oxidation.

Bellite is stated by the *Revue d'Artillerie* (of May, 1887) to produce its maximum effect when consisting of 15 per cent. dinotrobenzene and 85 per cent. ammonium nitrate (which is more nitrate than is required for complete combustion). Some trials of bellite have been quite recently (November, 1888) made in ironstone mines in the Cleveland district, and results obtained favourable to the use of bellite for blasting some kinds of mineral. The bellite used is said to have consisted of one part of dinitrobenzene and five parts of ammonium nitrate (this is about the proportion—1 : 4·76, —for total combustion to CO_2 and H_2O). From the experiments described (*Engineering*, Nov. 9, 1888, p. 462), bellite seems capable of doing a large amount of total work, its action extending over a wide range, but its rate of detonation would seem to be comparatively slow. There are, of course, applications for which this comparative slowness would be valuable.

I have gone into some detail about bellite, because it may be taken as a type of these nitrate of ammonia explosives, and there is more experimental detail to hand about it than about some of the others.

I cannot do more than mention the very similar *Securite*, patented by H. Schöneweg (Eng. Pat., May 18, 1886, No. 6664). His proposal to use oxalic acid, or oxalates, in combination with *securite*, or other explosives, to obtain an explosive said to be flameless, has already been mentioned.

I must mention the remaining explosives rather hurriedly, and with less detail than I should have wished, and first:—*Roburite*, which was patented in 1886, by Dr. E. Roth (German Pat., D.R.P., No. 39511, April 20, 1886. Eng. Pat., Provisional Specification, July 14, 1886, No. 9766; complete specification, Feb. 21, 1887, No. 2679), and which has this interesting point of difference from the explosives just mentioned, that *chlorinated* nitro-derivatives of aromatic hydrocarbons, or phenols, are employed in admixture with a nitrate. In his provisional specification, Roth states that he has proved, by numerous experiments, that (in roburite) the dynamic effect is considerably increased by the use of *chloro*-nitro compounds, probably (he states) in consequence of the increase in the volume of gas produced. He gives six examples of the commercial preparation of these chloro-nitro compounds, and states (in effect) that they are to be mixed, according to the carbon and hydrogen present, with about 2 to 3·5 parts of a nitrate, the mixture to be detonated by means of fulminate of mercury.

The roburite actually in use is, I believe, a mixture of chlorinated dinitrobenzene with ammonium nitrate. From the accounts given of the use of roburite, there appears to be a useful field for it in coal blasting, for which application the claim of safety is made.

Romite (the name probably from ῥώμη, *strength*) is an explosive patented by R. Sjöberg, of Stockholm (Eng. Pat., 11th Jan., 1887, No. 448, and 27th Aug., 1887, No. 11658); and, in the latter specification, stated to be prepared from ammonium nitrate, which is mixed with a solid, melted hydrocarbon (naphthalene, paraffin, and the like), and gelatinised by paraffin oil, together with pure or similarly gelatinised potassium chlorate, for which latter salt a crude nitrolactin (nitro-milksugar) may be substituted. In actual practice, I believe that romite consists of ammonium nitrate, naphthalene or ntiro-naphthalene, and paraffin oil; to be mixed

with potassium chlorate, or with nitrolactin at the place where it is to be used.

Kinetite (the name no doubt from κινέω, "*I move*") was patented by T. Petry and O. Fallenstein (their English patent is No. 10936, August 6th, 1884). As described in their specification kinetite is made by dissolving gun-cotton in nitrobenzene, or other liquid benzene or benzenoïd nitro-compound; the jelly thus formed is mixed, by kneading, with finely-powdered potassium chlorate or nitrate (or other metallic chlorate and nitrate), sulphur in the free state or as sulphide, is added, and the whole well kneaded. The proportions proposed were 16 to 21 per cent. of the aromatic nitro-compound, $\frac{3}{4}$ to 1 per cent. of gun-cotton or other form of nitro cellulose (these two constituents forming a 5 per cent. gun-cotton jelly), $82\frac{1}{4}$ per cent. to 75 per cent. of alkaline chlorates and nitrates, 1 per cent. to 3 per cent. of sulphur as antimony pentasulphide.

In actual use, I believe, the proportion of potassium nitrate to chlorate is small. Subsequently, at least in the kinetite for use in this country, the pentasulphide of antimony was omitted for the sake of increased safety. Dr. Dupré found it to be too sensitive to concussion; and I believe I am correct in stating that it has not up to the present been licensed in this country. From the statements made about it, kinetite appears to need for its use a powerful detonator and confinement.

The solvent action of nitrobenzene towards gun-cotton, even in the cold, is remarkable. Here is a 5 per cent. gun-cotton jelly, the gun-cotton was added as yarn to the nitrobenzene about an hour since; the former too is mainly trinitrocotton.

Rackarock is one of Dr. Sprengel's potassium chlorate explosives, described in 1873 in his paper to which I have frequently referred. It received the name of rackarock in the United States, where it was used in 1885 for the blasting of Flood Rock, Hellgate, which had always been a source of danger to vessels entering New York Harbour. It consists of a nitrobenzene absorbed in, or mixed with, powdered potassium chlorate. Nitrobenzene requires additional oxygen to the amount of 162·6 per cent. of its weight to be supplied to it for its complete combustion to CO_2 and H_2O; the following equation for its complete combustion by potassium chlorate:—$6C_6H_5NO_2 + 25KClO_3 = 36CO_2 + 15H_2O + 6N + 25KCl$. requires a mixture of the chlorate and nitrobenzene containing 19·4 per cent. of the latter.

General Abbot (United States Engineers) experimented with a number of mixtures with varying proportions of the two constituents; they were hand-mixed, and detonated under water, the charges being loosely compacted in tin cans. The intensity of action of the mixtures was found by the compression of the lead "crushers" of his well-known "ring apparatus;" the greatest effect was produced by the mixture of 21 per cent. nitrobenzene, with 79 per cent. potassium chlorate. This is a close approach to the calculated proportion (19·4 per cent.) just given. The intensity of action of rackarock (the 21 per cent. mixture) detonated under water in a thin case (a tin can) General Abbot found to be about 108; kieselguhr dynamite No. 1 (containing 75 per cent. of nitroglycerin) being = 100. (General Abbot, Addendum III. to his Report.) For the blasting of Flood Rock, 107 tons of rackarock and 300 tons of dynamite were employed. The rackarock was used in 6-lb. cartridges, into each of which a priming cartridge was inserted; in the dynamite cartridge was a thin copper shell, containing fulminate of mercury. The rackarock cartridges were not fired electrically, but by the shock (or by the "sympathetic explosion") of separate electrically-fired dynamite cartridges. Time fails me to give more details of this interesting operation, which was most successfully carried out by the United States Corps of Engineers on October 10th, 1885. Rackarock has also been used in another important civil engineering work: the making of the Vosburg Tunnel, in Pennsylvania. The tunnel, which is a long one (3,902 feet long), was commenced in 1883 and finished in 1886; rackarock was used in the headings, and Atlas powder for the remaining portion of the work.

Mr. W. D. Borland proposes to add about 5 per cent. of his cork-charcoal to this explosive; he claims that it makes the mixture plastic, and increases the rapidity of detonation. (See his carbos-dynamite specification.)

Picric Acid.—The fact that picric acid may be detonated by means of fulminate of mercury was first recorded by Dr. Sprengel in 1873 (see his paper of that year, "Journal of the Chemical Society," p. 803). He remarks that it is a powerful explosive when fired by a detonator.

The use of picric acid (without any admixture of oxidiser) has been patented by E. Turpin (Eng. Pat., 1885, Dec. 8th, No. 15089), its use in the fused state, or agglomerated by collodion and moulded, being especially recom-

mended. He proposes the use of a detonator containing 1·5 gramme (about 23 grains) of fulminate of mercury as answering well for picric acid in dry powder; but for cast or agglomerated picric acid uses an intermediate priming of picric acid in powder.

Picric acid is a powerful explosive, and the high specific gravity of the cast acid (1·6 to 1·7) gives it an advantage when comparison has to be made *by volume*.

Commercial picric acid melts at about 119° C. (246° F.). Here is a small quantity (an ounce or two) melted by means of a suitable bath of liquid; in the melted state the acid is a yellow liquid. We will make a cylinder of it by pouring it into this mould.

The acid heated by itself burns with a smoky flame. It has long been known that potassium picrate, lead picrate, and other picrates, would detonate on heating. Dr. Dupré made the interesting observation that a mixture of two parts by weight litharge (oxide of lead) with one part picric acid detonates violently when heated. I will heat one grain of this mixture on this piece of tin-plate, and this quantity will be sufficient to give a very sharp explosion. The very serious explosion which occurred at Messrs. Roberts, Dale, and Co.'s works at Cornbrook, near Manchester, was considered by Colonel Majendie to have been caused by the detonation of such a litharge and picric acid mixture, made by the flowing of the melted acid into the litharge present in the same room. For details of experiments conducted for the Home-office by Dr. Dupré and Colonel Majendie, in association with Sir Frederick Abel, I must refer to Colonel Majendie's Report, dated 15th Aug., 1887.

I will conclude with the mention of *Ammonio-nitrate of copper*, $4NH_3, Cu(No_3)_2$, which has been proposed and patented, as an explosive, by Mr. A. Nobel (Eng. Pat., 1887, Dec. 8th, No. 16920). He states that, while this chemical compound has long been known, it has never been understood to possess explosive properties, but he finds that it can be exploded by a fulminate detonator, and that it is capable of exercising very great power, and gives a very short flame of comparatively low temperature. The explosion must result from the oxidation of NH by the nitrate of copper, the H and O are in the proportion for complete combustion.

I may mention, however, that it is on record that the ammonio-nitrate, and the double nitrate of copper and ammonium $(Cu(NO_3)_2.2NH_4NO_3)$ explode when heated.

DISCUSSION.

The CHAIRMAN said the subject treated in this paper was a vast one, and, in fact, in no branch of science had greater strides been made, within a comparatively small number of years. For fifteen years after gun-cotton and nitroglycerin were discovered by Schonbein and by Sobrero very little use was made of those substances, and not until scientific investigation was brought to bear on their behaviour as explosives did their practical application develop. Since, however, we learned how to use these materials in various forms, other important chemical compounds had come into practical use, the employment of which a few years ago was scarcely dreamed of. Substances which, in some instances, were nothing more than chemical curiosities, were now in extensive use. Some of these were applied to important industrial purposes, quite distinct from their properties as explosives. For example, picric acid had been long used as an important colouring matter. In some instances such materials were already used on a large scale as explosives; in others, only to such an extent as to give promise for the future.

Mr. REID asked what was the particular advantage which had been derived from Von Förster's method of waterproofing gun-cotton. It was perfectly capable of being detonated in the wet state, and, therefore, he did not see the advantage of waterproofing it.

Mr. DEERING said he was not aware of any advantage, and he understood that Von Förster had himself returned to the method of coating primers with paraffin, only gelatinising the hole for the detonator with acetic ether. He had mentioned several things in the paper without intending to recommend them, but simply as matters on which information might be desired, and this was one of the most striking propositions which had been made with regard to gun-cotton.

Mr. BLOXAM asked if any information could be given with regard to smokeless powder.

Mr. DEERING said he had not touched on the subject for more than one reason. It was rather a delicate subject to deal with, being still under consideration and experiment, and he had quite as much matter as he could deal with apart from it. Most smokeless powders were either gun-cotton treated in some particular way, or some form of nitrocellulose.

Mr. PRICE EDWARDS said he had hoped to obtain some information on one or two practical points, particularly as to the best kind of explosive to use for particular descriptions of work. He had

not been able to find any definite statement as to the relative strengths of different materials, nor how they could be measured, which information would be very useful to many persons. He should also be glad to know if there were any explosives which were specially safe when stored; he knew that some were very dangerous to keep and manipulate, whilst others were much safer to handle. Another very important point was as to the use of explosives under water. He had been told that the best, or one of the best, ways was to put the explosive in india-rubber bags, and he should be glad of any information on that point. It was often used in this way for the purpose of destroying wrecks or submarine obstructions, and in such cases it was often desirable to have a substance which would produce its maximum effect in a downward direction, but he believed this was often produced by the superincumbent weight of water. Lastly, he would say that as explosives were often required for making fog-signals, it was desirable to know which was the best for that purpose, and the one which would produce the most intense sound wave.

Mr. DEERING said he had referred in his paper to the use of a massive lead cylinder, by the detonation of explosives in which, Sir Frederick Abel and others had gained very valuable information as to the comparative intensity of action of different explosives. With regard to the use of explosives under water, General Abbot's well-known work on the use of explosives for harbour defence contained a table showing the energy exerted by different materials used in 35 lb. charges, as measured by the compression of small lead cylinders. The method of measuring the intensity of the force must depend on the work in hand. For rock blasting, if the seams were pretty homogeneous, one would measure the cubic yards of rock blasted per unit of weight of the explosive used. Damp gun-cotton was probably the safest explosive of any; it could be stored in the wet state, and could be detonated at any time by a dry primer. An india-rubber bag would answer very well for use under water with a sharp explosive in superficial contact with the timbers of a wreck. General Abbot's tables showed that the intensity was rather greater, in most cases, in a vertical direction upwards, and was less than either horizontally or downwards. As a good material for sound signals, there was gun-cotton and tonite; he should think for such purpose the sharper the rate of detonation the better. He did not think there was anything purchasable better than gun-cotton, or preparations of it, which would include tonite.

The CHAIRMAN said he would add a word or two to supplement Mr. Deering's reply to Mr. Price Edwards. The application of explosives to fog-signals was made the subject of a very careful inquiry by the Trinity House, with Dr. Tyndall as *collaborateur*, and a very large number of experiments was carried on with gunpowder used in various ways, and with gun-cotton in various forms. As the broad result of these experiments, it was found that preparations of gun-cotton, such as nitrated gun-cotton, or tonite and potentite, gave the best penetrating sound, capable of being transmitted to considerable distances, even under somewhat unfavourable conditions. The fog-signals now generally used were made of either compressed or nitrated gun-cotton. India-rubber bags had been largely used for some time past by the Royal Engineers in submarine operations, and had proved thoroughly efficient. There was no difficulty in getting them to withstand the water pressure, and in applying them very readily so as to bring the explosive agent into as advantageous a position as possible for action at considerable depths. There were many topics in the paper, which had been scarcely touched upon, which would have furnished matter for interesting discussion, and one could but regret that so short a time could be given to so interesting a subject. The question of smokeless powders, for example, had not been at all dealt with. He might observe that the new sporting powders which were so well-known were the parents of many of the smokeless powders which had been brought out of late years. Such powders were now no longer a secret, for patents had been published with regard to them. The great difficulty was to manufacture them by simple processes on a large scale, so as to secure the uniform attainment of high velocities, and at the same time the development of only moderate pressures. Many men of great ability were working at this subject, and he had no doubt that for many purposes, for small arms especially, there would be before long comparatively smokeless powders, upon which perfect reliance could be placed, both with regard to stability, and to certainty and uniformity of action. He concluded by proposing a vote of thanks to Mr Deering for his valuable paper.

The vote of thanks was carried unanimously, and the meeting was adjourned.

Miscellaneous.

PRATT INDUSTRIAL INSTITUTE, NEW YORK.

The following particulars respecting the Pratt Industrial Institute, Brooklyn, New York, are taken from a description with illustrations in the *Scientific American*:—

The Institute has been founded, in his lifetime, by Mr. Charles Pratt, who had, during his struggling youth, experienced the need of such an institution that should afford technical education combined with

manual training. The buildings of the Pratt Institute, the most important enterprise of its kind, contain from three to four acres of floor space, and vary in height from one to six storeys. The main building is a brick and terra cotta structure 100 feet wide by 50 feet deep, with the department of mechanical arts behind, covering an area of 247 feet by 95 feet. The buildings are substantial and practically fireproof and are provided with all modern appliances for electric lighting, heating, ventilation, &c., as well as a large elevator for persons and goods.

The land was purchased in 1884; and the Institute was finished last year, the charter being granted on 19th May, 1887, with power to confer decrees. In addition to the facilities for technical education, designed exclusively for scholars, there are for the general public a free reading-room, a free library, and a technical museum, containing specimens of manufactured articles side by side with the crude materials from which they were made.

The Institute will accommodate several thousand students, who will be charged very low fees, all of which will be devoted to the support of the institution, which is also endowed with the rents from an apartment building known as the "Astral," most completely and perfectly arranged, which Mr. Pratt has put up at Greenpoint, L.I., at a cost of 400,000 dollars, or £100,000.

On the first floor of the main building are the library and reading-room; and a portion of the second floor is set apart for the offices, the remainder being arranged as a hall for lectures bearing on the work of the institution in all its phases, including right modes of living, political, social and domestic economy, sanitary science and ethics. While many of these lectures may be given as part of the regular course of instruction, others will be so arranged as to meet the wants of those not directly connected with the Institute, but who may desire systematic instruction in certain subjects.

The third floor is chiefly devoted to sewing, dressmaking, millinery and art embroidery, including instruction in hand and machine sewing, cutting and making plain garments. On this floor also are the departments of shorthand and type-writing, the instruction in which is both thorough and practical. The entire fourth floor and the art hall of the sixth floor are occupied by the school of art and design, in which pupils may pursue regular courses in drawing and painting, design, theory of colour, and artistic anatomy. As drawing is the basis of all constructive industries, pictorial art, and decorative design, this is one of the most important departments of the institution, instruction being given in sculpture and wood-carving, with special reference to the development of a high class of art work in bronze, copper, and stone.

The fifth floor is set apart for the technical museum, provided with oak cases, both vertical and horizontal, with air-tight plate glass doors, containing about 4,000 specimens of various wares in different stages of manufacture, the collection being most complete in ceramics. Copper, iron, tin, zinc, and other metals are shown in solid, filigree, inlaid, engraved and *repoussé* work, with the ores from which the metals were derived. The collection also includes minerals and a large number of crystal models in wood and glass, arranged to give an insight into mineralogy.

On the sixth floor is the art hall for advanced free-hand drawing and painting, as well as for the exhibition of art collections. Upon this floor also are two schools of cookery, provided with all the appointments of a well-ordered kitchen, including range, gas stoves, and refrigerators. Under the sky-light in the central portion of the rooms are large cooking tables with a complete assortment of utensils, so that twenty people can work at once in the same room. There are three courses of twelve lessons each, advancing regularly from the simplest to the more elaborate dishes; and in connection with every lesson a brief explanation is given by the teacher of the chemical and nutritive properties of the substances used, the changes produced by cooking, &c. In front of the cooking rooms is the lunch room, where a simple meal, well served, is furnished to teachers and students for a small sum.

The department of mechanical arts is designed for three classes of pupils, viz.:—(1) members of the regular three-years' course, who will receive instruction in wood and iron work, joinery, pattern-making, wood turning, moulding, casting, forging, &c. (for the girl students decorative work in wood and metals, cooking, sewing, dressmaking, &c., being substituted); (2) pupils from other schools who desire to supplement their studies by manual work; and (3) those who are employed during the day, but wish to utilise their evenings in acquiring a thorough knowledge of the methods and processes of the industrial arts. The buildings devoted to this department cover a ground space of 250 by 100 feet, the basement containing two 100-horse boilers for heating and for supplying the engines, which with the dynamos are also in the basement. On the first floor is the smiths' shop 73 by 29 feet, and 18 feet high, provided with ventilating sky-lights and an exhaust fan for taking away the fumes and smoke. Adjoining the smiths' shop is the foundry, 66 by 29 feet, in which practice is given in green sand, dry sand and loam moulding, as well as in core making. The machine shop, on the same floor, has bench room for forty-eight pupils, and a full complement of machine tools.

The wood-working department, which occupies the second floor of the same building, is provided with 150 feet of wall benches and thirty-six single benches, all supplied with the latest and most approved wood-working tools, while several circular and scroll saws, lathes and other machines are disposed about the floor. The third storey is devoted to laboratories and class rooms, and the fourth to advanced art work in metals and engraving; but this last department is not yet organised.

The department of building trades, occupying the remainder of the Institute, is designed for the instruction of pupils in bricklaying, modelling, stone carving, the construction of frame buildings, plumbing, &c., all the students being required to sketch their designs, and model them in clay, before executing them. The plumbing section can accommodate fifty-four pupils, the instruction being so complete as to amount to a course in sanitary engineering. A department of electrical engineering is soon to be inaugurated; and other departments will be added as circumstances may require.

*ELECTRICITY AS APPLIED TO MINING.**

By Frank Brain, M.E.

This paper is written from the mining engineers' standpoint, briefly sketching the known applications of electricity to mine-working up to the present date.

The writer regrets that there is very little known to add to what has already been made public. He cannot but express surprise that a power which it is apparent has now passed the range of experiment, and is developing itself economically and efficiently, should not have been made greater use of than appears to have been the case hitherto.

The recommendations of the Mines Commission, and the passing of the more stringent Coal Mines Act of 1887, have both stimulated mine managers to inquire into and recognise the advantages of electricity for blasting and lighting. By means of a small hand magneto-battery and electric fuses all the shot-firing in most of the fiery collieries is now done, the explosive used being one of the many lately introduced which, fired by an electric detonator, give off no flame. Dynamo machines at many pits are used for lighting the surface and main roadways of the colliery, and this current has also been used for the purpose of shot-firing, notably at Ynyshir Colliery, Rhondda Valley, South Wales. All the shots are fired in this way simultaneously, with every man out of the pit, thus putting loss of life beyond possibility. This adaptation, it should be said, however, is protected by a patent.

The adoption of the electric lamp in place of the well-known ordinary safety lamp is now very strongly advocated. There are several in the field, notably the Swan and Pitkin, using secondary batteries, and the Scharschieff, using a primary battery. The South Wales Institute of Engineers, who with other kindred societies have lately had these and other electric lamps before them, have referred the matter to a Special Committee to inquire into and report upon. Several colliery engineers in South Wales are practically testing them, one, Mr. G. W. Wilkinson, of Risca, having several hundreds in daily use. So satisfied is he with their results that an order has been given for a still further number.

The applications of electricity to transmission of power are confined to a few collieries, so far as the writer knows—in Great Britain to three only, viz., Trafalgar Colliery, Forest of Dean; St. John's Colliery, Normanton; and Allerton Main Colliery, near Leeds. At Trafalgar, what was a very small pumping plant, started in December, 1882, developed, by May, 1887, into three sets of plant, doing the underground pumping of the colliery, and that at a saving of some £500 per annum. At St. John's, a six horse-power set of pumping plant did such excellent work that a 33 horse-power was put down in March last in another part of the colliery, and has since been in continuous work.

These extensions speak for themselves. In each case the power is conveyed by cables from the dynamo at surface to the pumps placed at a considerable distance underground. At Allerton Main, very small quantities of water are being dealt with at inaccessible points. The power is supplied to the motors from secondary batteries charged at the surface, and conveyed to the required points in the colliery tubs or carts. A coal-cutter is also being driven by the same method.

On the continent underground haulage at Zaukeroda Colliery has been successfully and economically working since 1882, and also at Hohenzollern Colliery since 1884, the cost in each case being much less than by horses.

In America, where electric tramways are now numerous, the writer has not been able to obtain particulars of but one application to mining; this is a railway on the same system as the Zaukeroda. The electric locomotive receives the current from an overhead conductor, the return current to the dynamo passing through the rails. It is at a Short Mountain Colliery in the Wisconisca mines, and has been working satisfactorily since April, 1887.

There has lately been put in operation at Big Bend, on the Feather River, Butte Co., California, the most stupendous set of electric mining plant, so far as the author knows, in existence. A large river has been tapped, and with a fall of 300 feet it gives hundreds of horse-power by means of Pelton wheels. These actuate electric generators, from which the currents are sent along a circuit of 18 miles, driving Sprague motors at 14 different points where power is required in a mining district for pumping, hoisting, &c.

The falls at Roaring Fork, Grand River, are utilised for driving an electric generator, from which the power is conveyed across country over a mile to Aspen Mines, Colorado, where a 10 horse-power Sprague motor is driving the mine machinery, replacing steam power with considerable economy.

A gold mine in New Zealand has recently been made valuable by transmitting the power from a waterfall two miles away. The conductors, supported on poles, are carried direct over the mountains, 2,000

* Paper read before Section G. of the British Association.

feet intervening between the fall and the mine. Obviously, where water power can be thus applied the saving as compared with using fuel is considerable, especially in metal or diamond-mining districts, where coal is expensive. The ease with which the power can be conveyed over hill and dale, and into the intricacies of the mine, is, too, a factor of no mean importance.

It will be seen from the above how meagre are the results in transmission of power up to the present, and yet in every case where it has been adopted it has proved economically successful.

Possibly in fiery mines some are afraid of the sparks. There is no danger whatever on this head, as all the machinery can be enclosed in an air-tight chamber. It may be that want of familiarity hinders; they fear to embark capital in plant of which they cannot speak from their own experience.

The failures in the history of electric lighting have no doubt prejudiced some, who look upon the electric light and all akin to it with suspicion. The writer will be amply repaid if he can by means of this brief paper so interest some mining engineers as to cause them to take up the matter for themselves. He is satisfied that, under many conditions common in colliery working, electricity can and will be applied successfully and economically.

MEETINGS OF THE SOCIETY.

ORDINARY MEETING.

Wednesday evenings, at Eight o'clock :—

DECEMBER 19.—"Standards of Light." By W. J. DIBDIN, F.I.C., F.C.S.

CANTOR LECTURES.

Monday evenings, at Eight o'clock :—

Captain W. DE W. ABNEY, C.B., F.R.S., "Light and Colour." Four Lectures.

LECTURE IV.—DECEMBER 17.—The action of light on pigments.—The cause of change.—The effect of sunlight, sky-light, and artificial light.—Rays effective in causing change.—Moisture and oxygen necessary to cause change.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, DEC. 17...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Captain W. de W. Abney, "Light and Colour." (Lecture IV.)

Geographical, University of London, Burlington-gardens, W., 8½ p.m. Colonel R. G. Woodthorpe, "Explorations on the Chindwin River, Upper Burma."

British Architects, 9, Conduit-street, W., 8 p.m.

Actuaries, The Quadrangle, King's College, W.C., 7 p.m.

Medical, 11, Chandos-street, W., 8½ p.m.

Asiatic, 22, Albemarle-street, W., 4 p.m.

London Institution, Finsbury-circus, E.C., 5 p.m. Sir W. Wilson Hunter, "The New Forces in India"

TUESDAY, DEC. 18...Civil Engineers, 25, Great George-street, S.W., 8 p.m. Mr. J. A. F. Aspinall, "The Friction of Locomotive Slide-Valves."

Statistical, School of Mines, Jermyn-street, S.W., 7.45 p.m.

Pathological, 53, Berners-street, Oxford-street, W., 8½ p.m.

Zoological, 11, Hanover-square, W., 8½ p.m. 1. Mr. G. B. Sowerby, "Descriptions of 15 New Species of Shells, from China, Japan, and the Andaman Islands, chiefly collected by Deputy Surgeon-General R. Hungerford." 2. Mr. Herbert Druce, "List of the Lepidoptera-Heterocera, with descriptions of the New Species, collected by Mr. C. M. Woodford, at Aola, Guadalcanar Island, Solomon Islands." 3. Mr. J. H. Leech, "The Lepidoptera of Japan and Corea." Part II. Heterocea. 4. Dr. Hans Gadow, "Some Remarks on the Numbers and on the Phylogenetic Development of the Remiges of Birds."

WEDNESDAY, DEC. 19...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. W. J. Dibdin, "Standards of Light."

Meteorological, 26, Great George-street, S.W., 7 p.m. 1. Mr. Charles Harding, "Note on the Prolonged Spell of Cold Weather from September, 1887, to October, 1888." 2. Rev. T. A. Preston, "Report on the Phenological Observations for 1888." 3. Capt. D. Wilson-Barker, "A Winter's Weather at Massowah."

Geological, Burlington-house, W., 8 p.m. 1. Mr. F. A. Bather, "*Trigonocrinus*, a New Genus of Crinoidea from the 'Weisser Jura' of Württemburg, with Description of New Species, *T. liratus*, and Appendix I., Sudden Deviations from Normal Symmetry in Neocrinoidea; and Appendix II., *Marsupites testudinarius*, Schl., sp." 2. Dr. George J. Hinde, "*Archæcyathus*, Billings, and other Genera allied thereto, or associated therewith, from the Cambrian Strata of North America." 3. Dr. Andrew Dunlop, "The Jersey Brick Clay."

Royal Society of Literature, 21, Delahay-street, W., 1 p.m.

Civil and Mechanical Engineers, Westminster Palace Hotel, S.W., 7 p.m. Mr. W. A. Eckersley, "Notes on the Oroya Railway in Peru."

Inventors' Institute, 27, Chancery-lane, W.C., 8 p.m. The Hon. Secretary, (1) "Some Matters connected with the New Patents Bill, &c.;" and (2) "Some Recent Inventions suitable for the Household."

THURSDAY, DEC. 20....Royal, Burlington-house, W., 4½ p.m.

Linnean, Burlington-house, W., 8 p.m. 1. Mr. J. G. O. Teppu, "The Natural History of the Kangaroo Island Grass Tree." 2. Mr. Spencer Moore, "Apyocistis a Volvocinea." 3. Mr. G. B. Sowerby, "Some New Species of Shells."

Chemical, Burlington-house, W., 8 p.m.

London Institution, Finsbury-circus, E.C., 6 p.m. Prof. C. Stewart, "The Life History of Some Animals."

Sanitary Institute, 74A, Margaret-street, W., 5 p.m. Mr. Ernest Hart, "The New Local Government Bill and the County Councils, especially in relation to Sanitary Administration."

Historical, 11, Chandos-street, W., 8½ p.m.

Numismatic, 4, St. Martin's-place, W.C., 7 p.m.

FRIDAY, DEC. 21...Philological, University College, W.C., 8 p.m.

Journal of the Society of Arts.

No. 1,883. VOL. XXXVI.

FRIDAY, DECEMBER 21, 1888.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CANTOR LECTURES.

The fourth and concluding lecture of the course of Cantor lectures on "Light and Colour," was delivered by Captain W. DE W. ABNEY, C.B., F.R.S., on Monday evening, 17th inst. The lecturer dealt more particularly with his recent investigations connected with the action of light upon pigments.

On the motion of the CHAIRMAN (Mr. B. Francis Cobb), a vote of thanks to Captain Abney for his valuable lectures, and for the beautiful experiments by which they were illustrated, was carried unanimously.

JUVENILE LECTURES.

All the tickets for these lectures having now been disposed of, the issue is stopped. As all the available accommodation will be required for those members who have applied for tickets, it will be understood that no member can be admitted without a ticket.

COVERS FOR JOURNAL.

For the convenience of members wishing to bind their volumes of the *Journal*, cloth covers will be supplied post free for 1s. 6d. each, on application to the Secretary.

LIST OF MEMBERS.

The new edition of the List of Members of the Society is now ready, and can be obtained by members on application to the Secretary.

Proceedings of the Society.

FIFTH ORDINARY MEETING.

Wednesday, December 19th, 1888; JOHN HOPKINSON, M.A., D.Sc., F.R.S., in the chair.

The following candidates were proposed for election as members of the Society :—

Beattie, William, 15, Holden-terrace, Pimlico, S.W.
Dobson, James, 42, Old Broad-street, E.C.
Evill, John Percy, 26, Collingham-gardens, S.W.
Gonzalez, Enrique, 128, Sutherland-avenue, W.
Kent, William James, Johannesburg, South African Republic.
O'Malley, Thomas George, care of Dr. Holmes, 101, Leadenhall-street, E.C.
Palmer, Frederick Danby, Great Yarmouth.
Peyton, Edward George, 20, Maxilla-gardens, W.
Webster, Thomas, M.A., Temple-lodge, Queen-street, Hammersmith, W.

The following candidates were balloted for and duly elected members of the Society :—

Cole, Henry Ean, 1, St. James's-place, S.W., and The Cottage, Usk.
Jennings, George Henry, Westdene, Pendennis-road, Streatham, S.W., and Palace-wharf, Stangate, S.E.
Pope, Alex, 5, John-street, Adelphi, W.C., and Methven-house, King's-road, Kingston-on-Thames.
Scott, Archibald, South Bank, Surbiton, Surrey.
Woodhouse, A. E. C., M.R.C.S., 1, Hanover-square, W.

The paper read was—

STANDARDS OF LIGHT.

By W. J. DIBDIN, F.I.C., F.C.S.

The great importance attaching to the measurement of light in these days of severe competition between various luminous agents, renders it imperative that the question should be kept well in view, to prevent its being lost in the whirlpool of political changes. To many of the public the question doubtless appears to be one of those with which scientific men like to amuse themselves, but which can by no possibility have any effect on the practical details of our daily life. To show the immense commercial importance of the question in this City of London alone, it is only necessary to put forward the facts relating to the gas supplied by the three large companies, viz., the Gas Light and Coke Company, the South Metropolitan Gas Company, and the

Commercial Gas Company. In 1887, the amount paid by the public to these three companies for gas was £3,354,794. Practically the whole of this amount was for 16-candle gas, therefore £209,674 was paid by the public of London for one candle of light. When this item is added to the whole of the gas supply of the United Kingdom, it will be at once comprehended that in this seeming unimportant controversy we have one of the most far-reaching questions of the day; one in fact which, as soon as it is fairly grasped by the public, will have to be speedily settled. Up to the present it may be said that, in spite of the repeated inquiries, reports, papers before the various societies, and long correspondence in the newspapers, the question is still looked upon as merely pertaining to the laboratory of the professional photometrist.

The keen competition between the gas companies and the electricians, which is but beginning to rear its head, and promises to soon become a serious matter, demands a settlement of the value of our English unit, the sperm candle, and the provision of a substitute for it which will at once be reliable in working and capable of multiplication and repetition to an unlimited extent. Looking beyond our own nation, we see the question agitating the minds of conscientious workers in other countries. In France the "Carcel" lamp has held its own since its introduction in 1800, much in the same way as our sperm candles still maintain their pre-eminence here. In Germany, the paraffin candle (used, however, in a far more scientific way than are our sperm candles) still holds the field. In America, in this matter, they try all things, and anxiously watch the older countries for guidance.

When gas was unknown, and oil lamps and tallow candles ruled the roast, and the electric light was yet unborn, Bouguer, in 1760, proposed candles as the unit of comparison. In those days there were no official testing stations, and no boards of directors to harass unhappy gas managers. Had Bouguer lived now, it is open to doubt whether he would have been bold enough to have made the same proposition. Sixty-four years later Ritchie proposed wax candles, but does not appear to have worried himself about the rate of consumption. Tallow, paraffin, stearine, and sperm have been all tried, and finally in this country sperm candles, weighing six to the pound, each candle burning 120 grains of sperm per hour, were adopted.

The contradictory results afforded by the various candles and the Carcel lamp gave rise to numerous proposals for substitutes. Amongst these are the four-wick lamp of Potter; Keates's sperm oil lamp; Bunsen and Roscoe's carbonic oxide flame; Crookes's alcohol and benzol frame; Von Wartha's ether flame; Vernon Harcourt's pentane air-gas flame and lamps; Fiddes aperture, Wolf's screened moderator lamp; Hefner-Alteneck amyl-acetate flame; Methven's screened Argand flame; Edgerton's screened petroleum reading lamp; Rüdorf's screened Argand flame; Sugg's 10 and 16 candle tests (screened Argands); Dibdin's pentane Argand; Draper's, Zöllner's, Schwendlers, and Violle's incandescent platinum and silver units, and various electric incandescent lamps. For the purpose of ascertaining the quality of ordinary coal gas, various devices have been employed, such as the length of a gas flame at known pressures, *i.e.*, "jet" photometers, but these cannot be classed under the head of "Standards of Light."

By a process of the survival of the fittest, only the pentane, the Methven screen, the pentane Argand, and the 10 and 16-candle tests, are now before the public as practical proposals for substitutes for the sperm candle in this country. In Germany, the amyl-acetate lamp of Herr Von Hefner-Alteneck has met with great favour, and it would appear to have a good chance of being adopted as the legal standard. The objection of the English experts to the colour of the flame is so strong, that there does not appear to be any probability of its being adopted here. In France, the melted platinum unit, in the form proposed by M. Violle, has met with some favour, but nothing practical has arisen from it up to the present. I tried a modification of this proposal in connection with my experiments conducted under the direction of the Metropolitan Board of Works, in which I melted platinum foil by the oxyhydrogen blow-pipe flame, and took the light emitted at the moment of its melting as the indicator. This system was followed up by the Standards of Light Committee of the British Association, and elaborated by Mr. H. Trueman Wood, the secretary of this Society, who arranged the foil so that it could be melted by an electric current. The British Association Committee also tried a suggestion of Professor Dewar, which provided for the end of a thick rod of platinum being kept in a molten condition by the oxyhydrogen flame, and, while in that condition, being used as a standard after the manner of the Methven, a screen with a small circular aperture being

placed immediately in front of the molten bead of platinum. None of these methods, however, gave reliable results, and there does not appear to be much hope of such a standard ever finding favour in this country.

The Standards of Light Committee of the British Association for the Advancement of Science reported this year that, in their opinion, Professor Violle's molten platinum standard is not a practical standard of light, although they were quite prepared to agree to the adoption of the light emitted by a square centimetre of molten platinum as a unit, but not as a standard of light.

As it would be a work of supererogation to enumerate in detail all the work of the various official inquiries which have been made on the standards of light, I propose to discuss their results generally. The present official candles were described in the Metropolis Gas Act of 1860 as "sperm candles of six to the pound, each burning 120 grains per hour." If, in fact, each candle would confine its rate of combustion to that quantity, doubtless a great part of our difficulties would never have arisen, but as it is a matter for remark when we do get a candle to burn that precise quantity, we have to fall back upon an experiment for correcting the variations due to variable rates of combustion, *i.e.*, we weigh the candles before and after the experiment, and calculate the volume of light from the actual weight of sperm consumed in a given time. This method introduces the assumption that the luminous energy of a burning candle is always in proportion to the weight of sperm consumed in a given time. In order to avoid this assumption being too greatly strained, it is provided, however, that when the consumption falls below 114 grains per hour, or rises above 126 grains per hour, the test shall be rejected. The only other provision regarding the proper use of candles is that they shall attain "their normal rate of burning." The casual observer would probably assume that after all these precautions, surely the quantity of light emitted by a candle must be constant, within very minute limits. By referring to the reports of various experts and committees we shall see how far this is so. On the 25th August, 1881, the committee appointed by the Board of Trade reported "that candles are not of constant composition; that the melting point of the sperm varied; that the number and size of the threads in the wick, its treatment and closeness of plaiting of the strands, &c., affect the light of the candle, and that manufacturers differ in regard to them; that they found a difference of 15 per cent. in the average illuminating power of legal candles, and a maximum variation between two pairs of candles of 22·7 per cent." In 1883, the council of the Gas Institute appointed a "Standards of Light" Committee, and engaged the services of two of the most capable photometrists of the day, viz., Messrs. Heisch and Hartley. These gentlemen, after a most careful inquiry, in which they were assisted by the committee, reported that "In our experiments the differences in the indicated illuminating power by candles range from 1·3 per cent. to 16 per cent.; the average difference being 7·05 per cent. The maximum for 16-candle gas equals a difference of 2·56 candles; the average a difference of 1·128 candles. Such extremes as we realised are due to our resolve to study the behaviour of candles as sold for photometric purposes, which led us to use some, although they did not burn satisfactorily; specimens which in ordinary operations we should have rejected." The reporters then make a very important statement. They say:—"We may here mention what we are convinced to be a fact, namely, that sperm candles generally now develop more light per grain of sperm burned than they did several years ago."

In July, 1884, the Special Purposes and Sanitary Committee of the Metropolitan Board of Works instructed me to report exhaustively upon the important subject of the "Standards of Light," and in the following February I presented an interim report, from which the following extract is taken:—

"CANDLES.

"The numerous experiments of the two committees already referred to would seem to have rendered unnecessary any further experiments with candles with the view of showing their unreliability. This is indeed the case, but as not a few photometrists have expressed the opinion that candles have not been always fairly treated, I have thought it best to make a few additional tests in such a manner as to obviate all considerations of bias on the part of the observer, and to illustrate the actual results which are constantly obtained by gas examiners in daily practice.

"With this view I instituted two series of experiments, which were carried out on the 23rd, 25th, 29th, and 30th of October last. The object was to show—1. The difference in candles obtained from those makers who supply the bulk of candles used in photometry. 2. The variations obtainable when candles, burning within the prescribed limits, are

used precisely in the same manner, and by the same observers, as they are at the metropolitan gas-testing stations.

"The first series, Table II., demonstrates in a remarkable manner how the illuminating power of a given flame may be made to appear extremely variable. On the first day the average of tests with candles made by Firm A showed the illuminating power of a gas flame to be equal to 15·76, whilst candles manufactured by Firm B gave a value of 14·94 candles, a difference of 0·82 candle. On the second day a still wider divergence was found. Candles A gave a value of 14·81 to a constant gas flame, whilst candles B gave a value of only 12·86, or two candles less. It may be objected by the advocates of candles that the number of tests were insufficient, but, as I have stated above, these results have been so often confirmed that no useful result would accrue from their repetition.

"The second series, Table No. III., was designed to show the difference in the results when the average of three or more tests are taken. On the first day of this series the tests were made solely with the candles of one maker and from one packet. The greatest difference obtained in the average of three tests, each consisting of three complete observations, was 1·3 candle; the greatest difference between any two single observations was 2·0 candles. On the second day the observations were repeated, when the greatest difference in the average of three tests, as before, was only 0·31 candle; but the greatest difference between any two single observations was 1·33 candle, and this was with one candle. This candle alone gave such remarkable variations, not only in the hands of different observers, but also in the hands of the same observer, that it was sufficient in itself to throw great discredit upon the system. The following are the recorded tests, viz.:—

1st Observer	..	1st test	..	16·65
1st ,,	..	2nd ,,	..	15·67
2nd ,,	..	1st ,,	..	15·87
3rd ,,	..	1st ,,	..	17·00
3rd ,,	..	2nd ,,	..	16·70

"In consideration of the foregoing results, and the general experience of candles, I respectfully submit to your committee that the condemnation which they have met with is not undeserved; and that, as speedily as possible, they should be rejected as the standard of light."

In my second and final report, presented to the committee on the 3rd May, 1887, I stated that:—

"As will be seen from the tabulated results of the numerous experiments which have been made, viz., 2,120, involving over 20,000 recorded observations—candles, as the only legal standard in this country, have been systematically used, with the result of still more than ever proving their unreliability."

While this repeated condemnation of the candles, when used in the legal manner, admits of no saving clause, it is only right to put again on record the fact that when the operator is allowed to choose his own candles, rejecting those which are obviously incorrect, although falling within the limits of the Act; and to burn them in the open, instead of shutting them up in a closed box with insufficient ventilation, very different results are obtainable. In fact, to such an extent has this been found, that it would probably not be difficult to formulate a manner of using them, and it might seem desirable to try the effect of such regulations. The difficulties that would, however, arise between conflicting interests in making such regulations would probably be no greater than those in connection with the introduction of a new standard which should at once sweep away any uncertainty, and it is better therefore to work for a permanent change rather than for a temporary expedient, however desirable that may be.

Having arrived at the conclusion that the present legal standard is unreliable, it is necessary to inquire into the merits of the various proposed substitutes. Of these the pentane air-gas standard of Mr. A. Vernon-Harcourt undoubtedly holds the highest rank. This was first introduced in August, 1877, when Mr. Harcourt read a paper upon it before the Physical and Chemical Sections of the British Association, at their meeting held at Plymouth. On the 8th April, 1879, Mr. Harcourt forwarded to the Board of Trade, a letter accompanied by a statement of a series of tests made with the candles and the new standard. In consequence of this communication the Board of Trade appointed the committee to which I have already referred, who, after a very careful examination, reported that "Compared with the sperm candle, Mr. Harcourt's air-gas flame is exact and trustworthy as a standard of light." In 1883, the experts of the committee of the Gas Institute, Messrs. Heisch and Hartley, reported of this standard as follows:—

"We feel compelled also to say, although with reluctance, that we cannot regard Mr. Harcourt's standards as convenient, or at all suited for use in general photometry. They demand too much attention from the operator; with an ordinary photometer his attention is divided between the air-gas flame and observations of the disc, for it matters not how carefully either the prepared gas flame or the lamp flame be adjusted (even when the former is controlled by a governor), the flame length will change; and a little change is sufficient to produce a serious error. Besides

this, the flames are very sluggish and unstable. The least current of air affects them, and causes them to swerve from the perpendicular, and where this takes place observations at the photometer are useless. Further, they require a freedom from vibration of the room and of the apparatus which is rarely obtainable. . . . . We certainly expected that the experiments would have been favourable to Mr. Harcourt's proposed standards, and regret that the contrary is the case."

In view of this strong condemnation, I was very careful in my experiments, and after most thoroughly trying both the original air-gas flame and the lamp, I was most convinced that the above remarks could not be accepted as applying to the former. In my first report I stated that "From the beginning to the end of my experiments the whole of the tests were made with great facility; in fact I was agreeably surprised at the simplicity and convenience experienced." And again, "The important statements made by Messrs. Heisch and Hartley as to the unsteadiness of the pentane flame have received great attention. I have tried all that is possible to vary the height of the flame by any means likely to accidentally affect it. I have let heavy weights fall on the floor of the testing room; shut both inner and outer doors violently; the wall of the room has been struck; in fact, everything has been done, short of damaging the premises, to test the steady burning of the flame. Beyond a momentary leap at the instant of concussion, no effect whatever was produced; the flame burnt steadily, and the readings were the same after the experiment as they were before. I am not aware that my photometer room is of a peculiarly solid construction, or subject to less vibration than those at the testing stations. The only conclusion I can therefore come to is that the results obtained by Messrs. Heisch and Hartley are not of the nature of those which might be looked for in practice." In my second report, after more extended trials, I stated that "The pentane air-gas has completely borne out my former experience of it." "I have found the pentane air-gas to comply with every demand made upon it, and to answer to the full all the claims made for it by the inventor. The facts brought out by this inquiry have shown that the method of preparing the air-gas is at once easy and safe; that the measurement of the volume of gas used is simple and reliable, that the adjustment of the height of the flame is a matter of certainty; its steadiness all that can be desired when due care is taken and proper apparatus employed; and that the colour of the light afforded is precisely the same as that of the standard comparison flame." "Should it be desired to use the flame in an unsuitable position as regards draught, the use of a chimney, as arranged by the inventor, entirely obviates all difficulty as regards steadiness, and renders the flame absolutely steady and free from the slightest sign of vibration and swaying."

This last point, I consider of the greatest importance, and where necessary I should recommend the use of the chimney and cover in all practical work, as the use of an absolutely rigid flame, such as is thus obtained, renders the readings of the photometer infinitely more definite and sharp. In conclusion, I recommended the adoption of the pentane air-gas flame as a standard in the place of candles. As, however, many practical photometrists are of opinion that a standard of light of more than one candle is desirable for most purposes, and absolutely essential in some, I further recommended that when the legal substitution of the pentane unit for the present candle be made, the Board of Trade should be empowered to sanction and authorise the use of such other standards and substitutes as that Board may deem fit and proper to be used in place of, and after comparison with, the pentane air-gas flame.

The conclusions as to the fitness of the pentane air-gas as a desirable unit, arrived at by the Board of Trade Committee in 1887, and by myself in 1885 and 1887, have since been confirmed by the "Standards of Light" Committee of the British Association, who this year recommended its adoption.

In view of the possible adoption for practical work of a standard of higher value than the one candle pentane air-gas, it will be interesting to discuss the position of those proposals which seem to most nearly comply with the requirements of the photometrist. I have elsewhere stated that in my opinion it is most desirable that whatever standard may be used, it is advisable to avoid the use of common coal-gas as a standard combustible, and therefore I have rejected the plain gas two-candle unit of Mr. Methven and the coal-gas "ten candle test of Mr. Sugg." Fortunately, however, in so doing, it is not necessary to reject the principle of these convenient units, as the vapour of the pentane used by Mr. Harcourt supplies the means of providing a flame to each of these systems,

independent of coal-gas, or as an auxiliary to it. The now well-known "carburetted Methven" gives admirable results when the height of the flame is constant. Unfortunately, however, my experience of this standard is, that various operators may disagree as to the height of the flame, and a little over-discretion, or carelessness, as the case may be, will cause very different results.

At the time of the Board of Trade Committee, in 1881, Mr. Methven used the original pattern, in which simple coal-gas was burnt, and that committee condemned the system in consequence of the variability due to differences in the quality of the gas used. To obviate this objection, the inventor enriched the ordinary gas by causing it to take up the vapour of pentane, on its way to the burner, and altered the form of the slot to suit the enriched gas.

In speaking of these two forms of Mr. Methven's proposal, Messrs. Heisch and Hartley, in their report already referred to, said:—

"It will thus be realised that the range in the qualities of gases with which the Methven plain gas standard can be safely used is much wider than is generally supposed; as in our experiments the extremes are 13·65 and 22·4—a range of 8·75 candles. . . . The Methven standards are simple in construction, not liable to get out of order, and extremely easy to use. They do best—like candles—in an open photometer, but can be readily used in a closed one, if due care is taken to freely ventilate the photometer, and avoid violent air-currents—conditions which are extremely difficult to fulfil with closed photometers. . . . . The only conclusion which can be drawn from such a mass of evidence is, that the Methven units are not only perfectly reliable instruments in ordinary gas testings, but are suitable for use in photometric investigations of a much more refined character."

This is strong evidence, and leads to the conclusion that at all events here we have a valuable substitute for candles; the main objection to the method being the uncertainty as to the height of the flame. Were there no other proposal equally simple in character and free from the same objection, it would be conclusive. But in view of the fact that in the modified form of the "ten candle test," which I have called the "Pentane Argand," we have a most reliable standard, free from all objection from the "height of the flame" point of view, as I shall presently show; independent of coal-gas, and atmospheric influences, such as temperature or pressure; possessed of the advantage of being a decimal factor, viz., ten candles; and furthermore being a desirable unit to use in coal-gas testing during foggy weather, as the distance of the opposing lights from the photometer disc is for that purpose practically equal; the Methven would seem to have been distanced in the race by so formidable a competitor.

The arrangement possessed of these advantages is very simple, no meter, governor, or other measuring or controlling adjunct, beyond a simple tap, being necessary. It is merely a small Argand burner suited for burning air-gas. Supported 2.3 inches above the steatite burner is a screen to cut off the light emitted from the top of the flame, and indicating rods to assist in regulating the flame to a height of three inches. The standard combustible is the vapour of pentane; this is driven forward to the burner by a current of air from a holder or pressure bag, as may be convenient, about half a cubic foot of air per hour being required. The pentane is contained in a carburetter precisely similar to that of Mr. Methven's; in fact I used one of his pattern; and the air carburetted with the pentane in the same way that he carburetts the coal-gas for his later form of standard. A variation in the temperature of the carburetter makes no difference, as I obtained the same result when I filled the trough of the carburetter with water at 90° F., and then with ice and water. The flame should be adjusted to a height of three inches, for uniformity, but if from accident the flame falls to two and a half inches or rises to over four inches, no difference is observable in the volume of light emitted under the screen. I have ascribed this remarkable result to a compensating action in the blue portion of the flame, which is reduced in size when the luminous portion is lowered, and contracted in bulk, and thus causes a greater length of the white flame to be seen under the screen, and inversely, when the flame is raised and expanded in width, the blue portion is also increased, and thus compensates for the otherwise greater intensity of the white portion. From the manner in which this proposal has been received, I am in hopes that it may form a neutral ground on which, for a time at least, conflicting interests may meet to their mutual advantage.

The statement of Messrs. Heisch and Hartley already quoted, to the effect that candles develop more light per grain of sperm now than formerly, is a most important one, and cannot be passed over in silence, as

such a proposition will doubtless afford scope for serious contention. In my report, 1885, I referred to this point in the following terms :—

"I may now revert to the remarks of Messrs. Heisch and Hartley, as to the quantity of light afforded by candles being greater at the present time than formerly. I have put forward the results of the tests made for the purpose of standardising the 'Keates' lamp in the early part of 1879. Mr. Harcourt's pentane was standardised about the same time, or a little earlier. I find that these standards, as well as the 'Methven,' standardised in 1878, closely agree with a large number of candle tests. I also find that the 'Carcel' lamp, as compared with the 'Pentane' and 'Keates' lamp, is equal to 9·4 candles, while a number of tests made by Mr. Sugg, in 1870, showed its value to be 9·6 candles. I am, consequently, driven to the conclusion that the average quantity of light, per unit of sperm consumed, emitted by good candles, is practically the same as when the lamp, the 'Pentane' and the 'Methven,' were standardised, viz., in 1878 and 1879, and as when Mr. Sugg tested the 'Carcel' in 1870. So far from candles giving more light, the tendency is to give less light."

In my second report on the same point, I stated that :—

"The relative value of the pentane air-gas flame and candles was fully discussed in the first report to your committee, and there is every reason to believe that the result then arrived at was correct. It is generally admitted by those who formerly expressed an adverse opinion to the pentane unit, that the Methven screen is accurately adjusted to two candles. The results of the very numerous tests which have now been made with these two proposals clearly demonstrate that the Methven screen is an exact multiple of the pentane air-gas flame. Therefore, the Methven screen being equal to two average candles, and the pentane unit equal to half the value of the Methven, the pentane must be equal to exactly one average standard candle, which is the value claimed for it by the inventor. The average of the whole series of tests by candles, including all results, gave a mean value of 17·0 candles for the comparison flame. If, however, those tests which gave indications over 17·5 candles are excluded from the calculation of the average (as such tests as 18, 19, and 20 candles are self-evidently wrong), the mean value given to the comparison flame by candles is 16·7. The mean results of both the Methven and pentane air-gas units is 16·3 candles respectively, so that, after including in the tests by candles many obviously incorrect results, I find that there is only a difference of 0·4 candle, which difference may be unhesitatingly ascribed to faulty candles. The fact that candles frequently err from imperfect combustion of the volatilised sperm cannot be accepted as a reason for lowering the acknowledged value of the average standard candle."

That the average results by candles were too high is shown by the fact that, out of 81 averages, no less than 14 were above 17·5 candles, and 37 above 17·0 candles; results admittedly too high for an Argand flame only three inches in height. While, on the other hand, the average results by candles were under 16 candles only on six occasions, and on three of these, the low result was confirmed by the other standards; so that on only three days did the candles indicate results lower than would appear to have been the true value of the comparison flame.

The Report of the Standards of Light Committee of the British Association fully confirmed these results, and explained them upon the following grounds. Manufacturers endeavour to remove the liquid portions of the spermaceti ("sperm oil"), and thus obtain the "dry" spermaceti as free from it as possible. The resulting product has a higher melting point, and therefore burns with less facility The manufacturers have now so far succeeded in this direction that candles have to be made with larger wicks, the result being that they give less light for a given consumption than candles with smaller wicks. Thus the effect in the improvement in spermaceti candles has been that standard candles give less light than they gave ten years ago, and probably still less than they gave at earlier periods, when the average consumption of candles of six to the pound was 140 grains per hour.

Having now arrived at the point at which candles are shown to be untrustworthy, and a suitable substitute found in the pentane air-gas flame, aided, for practical purposes, by the pentane Argand, it may be of interest to glance at the position of the question on the continent. In presenting a Report of the Committee on Candles to the twenty-eighth annual general meeting of the German Gas and Water Society, in September last, Dr. Krüss stated that the committee thought to have fulfilled their instructions by establishing the German Society's paraffin candle, which had for the last year been manufactured under the society's direction at the works in Waldau; and that the society had determined no longer to issue six to the pound but ten, in order to obtain a length of candle more suitable for practical use. Each single candle was provided with a wick in perfectly central position, which is more easily accomplished

in the shorter candle than in the long one. Care had been taken that the new candles have exactly the same photometrical value as the former ones. While the work of the committee had been devoted to the control of the production of the standard candles, and to supplying these to the consumers, they had occupied themselves with the amyl acetate lamp, and had already come to the conclusion that it was an extremely comfortable standard for every-day use. This decision had been subsequently confirmed. From the results of a number of tests made by the members of the society generally, it was agreed that for daily use for the present there was no better, more practical and comfortable, and less time-consuming means for light measuring. It appeared, however, that the proportion of the intensity of the lamp to the different candles had not been accurately determined. The intensity of the German Society's candle was variously stated to be 1·2, 1·234, 1·21, 1·26, 1·12, and 1·20 amyl acetate lamps with 40 mm. height of the flame. Still greater differences had been found when comparing the English candle with the lamp. It was evident that further close and continuously systematic trials were necessary to determine its exact value. From a series of experiments conducted by Dr. Liebenthal, of Hamburg, it appeared that the measurements of the wick tube, and consequently the diameter and length of the wick, need not be adjusted with extreme accuracy, but that the height of the flame was very important, and that the mean variations between two amyl acetate lamps come within one per cent. The committee had therefore resolved in conformity with the experience up to the present, that the steadiness and easy application of the amyl acetate lamp, even in its present form, recommends it as a suitable means of comparison for light measurements, and that further trials are necessary, to determine the proportion between the intensity of the amyl acetate lamp and that of the candle. It was therefore proposed to constitute the Committee on Candles, a committee on light measurings to make these trials together with suitable experts, and that the Physical and Imperial Technical Institute of Charlottenburg be requested through the Imperial Board of Home Affairs to lend their co-operation in the investigation.

This decision is of great importance. From the results of the very numerous tests made by myself and others with the amyl acetate lamp, it is evident that its convenience and steadiness is all that can be desired, but, as I have stated, its colour is against it in the opinion of the English experts. Could this be overcome, it would be a very convenient standard, but all efforts up to the present have failed to produce a light of the character of that given by the pentane and candles at their best. From my experiments I found that the forty millimetres height of flame was too low, but on raising it to fifty-one millimetres or two inches, it gave results identical with the average English candle as determined by both the pentane and Methven screen.

I am informed by Dr. Krüss, of Hamburg, that while they agree that the colour of the amyl acetate lamp is very unfavourable, they did not know of anything better, and therefore had to put up with it. They are now trying the improved pentane lamp of Mr. Harcourt, but the experiments are not yet concluded.

One of the objections put forward to a change of standard in England is, that no general desire has been expressed to that effect. It has been already shown that the authorities of the Board of Trade—the controlling authorities for gas-testing purposes in London—the gas interest generally, as represented by the Gas Institute, and the British Association, have all joined in one condemnation of the existing candle, and in demanding an alteration, and, with one exception, that such alteration should consist in the adoption of Mr. Harcourt's pentane air-gas flame. It has also been said that no alteration can be made in London without affecting the country generally. If the regulations applying to the candles were general, that would be a strong argument, but at the present moment there are virtually two different standards in use. In the Metropolis Gas Act the standard candle is defined as "sperm candles of six to the pound, and burning at the rate of 120 grains per hour." In the instructions of the Gas Referees it is prescribed that the candles shall attain their "normal rate of burning," and no mention whatever is made of their *manner* of burning. In the Gas Works' Clauses Acts, 1871, however, which applies to the country outside the metropolis, it is specifically laid down that the tip of the wicks shall be glowing and slightly bent, and thus a distinct condition is indicated. True, most photometrists decline to use the candles in any other manner, but it has been repeatedly argued, on behalf of the gas authorities, that an examiner has no discretion provided the

consumption of the sperm is within the prescribed limits, so that a test is a perfectly legal one when the wick is upright, and the candle consequently giving less light, with the result of indicating a higher value to the gas than it otherwise would have. Such a condition of things does not argue well for the maintenance of uniformity in the manner of testing the value of the gas supplied in such enormous volumes to the public. If those outside the metropolis are satisfied with the better protection they now have, it is no reason why a less sufficient protection should satisfy the inhabitants of London. It cannot be imagined, however, that the general public of the country are aware of the present defective condition of the question. In all other matters affecting the commercial transactions of daily life, the most stringent regulations are in force to maintain almost mathematical accuracy in the various weights and measures used. In the matter of light alone the utmost laxity prevails, and when it is considered that such vast interests are at stake, it seems almost inconceivable that the legalisation of an accurate standard of light, such as can now be obtained, should be delayed for a moment longer than that required to take the necessary steps.

DISCUSSION.

Mr. VERNON HARCOURT, F.R.S., said he had heard a good many papers on this subject, and had read some himself, but had never seen one so well illustrated, the concluding illustrations (thrown on the screen), showing the various forms a candle-wick might take, being especially valuable. If this question were only a scientific one, no doubt it could be worked out satisfactorily, but for the business of gas-testing the standard required to be used was the very variable one just shown—the candle, and he feared this was likely to be the case until more public interest was shown in the matter. It was eight or nine years since the Board of Trade appointed a committee to inquire into and report on the subject, and the report was sent round to a number of persons in all parts of the country, who it was thought would be interested, asking for observations. Hardly any replies were received, and the Board of Trade concluded that very little interest was taken in the matter, and it was in consequence of this that nothing had been done since. The matter, however, was of considerable practical importance, and probably the best contribution he could make to the discussion would be to relate an example which had come under his own immediate notice. In the early part of this year, he received a letter from the Town Clerk of Gloucester, asking him to go down and find out, if possible, the cause of a difference of opinion, which had caused a great deal of unpleasant feeling in the city, with regard to the quality of the gas. There was a gas examiner to test the gas, and he made the value sometimes very near, and sometimes a little below the standard at which it ought to be supplied; whilst on the other hand, the testings at the gas-works led the gas company to maintain that the quality was considerably above the standard. This caused a great deal of hostile feeling, because, naturally, each side suspected the other, and were very confident of the correctness of their own tests. He went down and made testings with both photometers, everything being put freely at his disposal, and he satisfied himself that the testings had been made in the most careful and conscientious way, and with the most perfect *bona-fides* on each side. The gas examiner was a very keen but a very competent man; and no less pains were taken at the gas-works. In fact, the whole cause of the difference in results and consequent unpleasantness was the difference in the candles used. To some extent the difference was due to a variation to which Mr. Dibdin had alluded, viz., the liberty which one gas examiner would allow himself, and another would not, in dealing with the candles. Some men considered themselves at liberty to select, and would reject candles which did not burn as they should, while others took them as they came; and, of course, where the standard was liable to variation, it was obvious that the result would vary according as a selection was made or not. If one man made a series of testings with selected candles only, he would arrive at a different result from that obtained by another man who accepted the candles however they burnt. But besides that there was a considerable difference in the candles themselves. One candle had more threads in a strand of the wick than the other, and the more threads there were the less light would be given. He thus found that the unfriendly relations had arisen without any fault on either side, but simply from variations in the photometric results arising from the causes he had named.

Mr. ALEXANDER SIEMENS wished to say a word or two in favour of the amyl-acetate lamp, in spite of Mr. Dibdin's condemnation. As an electrician who often had to compare the power of different lights, he had found the simplicity of this light a great advantage, which was not wholly counteracted by the colour. In his experiments Mr. Dibdin had unfortunately increased the height of the flame from 41 to 51 millimetres, which made the colour worse. This lamp was not intended to be equal to a standard English candle, but one could easily be made a little larger which would give exactly an English candle under better conditions. Since supplying the lamp in question they had also found that the results depended on having perfectly pure amyl-acetate; and since sending it to Mr. Dibdin they had discovered that it was a bad consignment. For practical pur-

poses the German gas examiners had arrived at the conclusion that this lamp was about the best, especially for measuring gaslight, for it would be found that the colour of the lamp was very similar to that of gas; and was, therefore, all the easier to compare. The great difficulty in dealing with light was that the eyes of various observers were affected differently, and it was, therefore, very difficult to compare lights which were not exactly alike. To overcome this difficulty, a selenium photometer had been designed by Dr. Werner Siemens, which was based upon the well-known fact that selenium altered its electric resistance under the influence of light. In that case you had not to determine whether a spot was equally illuminated by two sources of light, but were guided by the action of a galvanometer, which was much more delicate, and gave more certain indications, and no doubt where great accuracy was required that would be the best instrument. He should also like to show the action of the platinum standard, which Mr. Dibdin had described; it was a strip of platinum behind an opening of one - tenth of a square centimetre, and the current was increased rapidly by dipping the zinc plates of a battery in chromic acid, instead of by taking out resistance as in the other apparatus shown. The light given from this aperture was about equal to one and a half English candle. This was not quite the same as the standard recommended by the French Conference, as this was melting platinum, not solidifying platinum.

Dr. DUPRE said the great thing in a standard was that yon could multiply it, and so get a standard as often as you wanted it, and he should like to ask Mr. Dibdin if this were the case with the pentane standard, would it be the same with different burners? With regard to the selenium test, he would say that after all it was the eye that had to judge, and the selenium had to be standardised. He did not think it was proposed to use selenium as the standard itself, and therefore you had to fall back upon some standard, either the old candle or the pentane flame. When once you had the standard it could be used in the same manner as the Methven screen, but it could hardly be used as a standard of itself.

Mr. WILLIAMS said it was some three or four years since Messrs. Siemens sent him an amyl-acetate lamp, with which he made a considerable series of experiments, and which convinced him that it was far superior to any other standard which had been proposed up to that time, not even excepting pentane, though, at the same time, he had not had much experience with Mr. Vernon Harcourt's pentane flame. He was quite aware of the fact that the amyl-acetate lamp was not equal to an English candle, and was rather surprised to find that Mr. Dibdin had turned the flame up, and so made the colour worse. Not only Messrs. Siemens, but other manufacturers in this country he believed, had set themselves to make lamps which should give a full candle; amongst others Messrs. Woodhouse and Rawson, and the Edison and Swan Company. The amyl-acetate lamp might be improved in several important respects. It should be made with a double wick, so that there should be two flames and then it might at once replace the standard candle; then the German silver tube which held the wick should be made of platinum, to prevent corrosion.

Mr. SIEMENS said this had been done.

Mr. WILLIAMS said another point was that the flame ought to start from a broader base, the tube should be about one millimetre wider, but the flame not raised any higher than at present. There was another point which applied not to these lamps only. Chimneys were very objectionable, for however carefully they were selected, they were almost always found to be badly annealed, and some parts refracted very differently. They contained striæ, and if these happened to come in the line of the pencil of light which was being measured, they produced a very injurious effect, and he feared this was not sufficiently taken account of. For such purposes, especially with the amyl-acetate lamp, he would recommend the use of a chimney which he had used for a long time, made of an exceedingly thin strip of mica; it might be so thin as to be almost invisible, as would be shown by the fact that if you balanced two lights against one another, and slipped a very thin mica chimney over one of them, it made no appreciable difference on the photometer. He had made some experiments with platinum, which did not even *à priori* seem likely to be a very serviceable standard. Very little was known as to the purity of commercial platinum, but a good deal was known as to the difference in the fusing point of various samples; and as the emission of light was distinctly a function of the temperature, it would necessarily follow that platinums of different fusing points would emit different quantities of light per unit of surface. Solidifying platinum would be better, if anything, than fusing platinum, because you could not tell how far you might superheat the metal at the moment of fusion. Perhaps before the public would consent to have candles condemned, they would demand that some more rigorous and scientific attempt should be made to improve them. He felt sure that if Mr. Dibdin were to invite a few of the most distinguished candle-makers to make the attempt, something might be gained in that way, and at any rate it would be an advantage in the interim before a new standard was adopted. Candles were faulty in two respects. Candle-makers objected to use pure sperm because it gave what they called a grain to the candle, and they always added a little wax to break the grain. Beeswax was generally added, but there was nothing to show that the composition should be constant. Secondly, with regard to the wicks, no definition was

given of the number of threads in the wick, the coarseness of the cotton-fibre, the tightness of the plaiting, or the special tension of the particular thread which caused the twist or curl. This last was probably the most difficult to adjust, but it was also the one which gave rise to most trouble in photometry. If the thread were too tight, you had the wick twisting very much indeed; on a recent occasion he had a lot of candles in which the wick twisted quite into a loop, and caused the candle to smoke. Of course, an experienced photometrist would reject a candle of that kind, but, as Mr. Harcourt said, some examiners allowed more latitude than others in this respect When burning, the candle should always show a nice curled wick, in a parabolic shape, the focus of the parabola bring the edge of the flame. The curve was a very pretty one, and if a photometrist had an eye to beauty, he would easily see when his candles were burning well.

Mr. Dibdin, in reply to Mr. Siemens, said he had not found that the colour of the amyl-acetate lamp was materially increased on heightening the flame, it might be very slightly increased, but when at the normal height, there was the colour as he had stated, and Dr. Krüss informed him that they agreed that the colour was unfavourable, but they had to put up with it for want of anything better. With regard to the pear oil, Messrs. Siemen had very generously sent him not only the lamp, but a supply of oil, but he had not confined his experiments to that, having tried another supply which he was assured was perfectly pure, and the colour of the flame was still maintained. He had not gone into the question of testing different colours, but he had elsewhere shown that there was no difficulty in testing lights of different colours, if you used a particular form of disc, known as Leeson's star disc, in the modified form he had lately advocated. As originally proposed, it was not the most convenient, but now certain defects had been overcome, and for different colours it was the most admirable arrangement you could have; positive blue and positive red could be compared with the greatest case. Dr. Dupré asked if one could obtain the same results with different burners. That was one of the most important questions, and one which had been carefully attended to. He had used various burners, and had obtained precisely the same results, and he could not see how very slight variations could make much difference. He could not agree with Mr. Williams as to the desirability of improving candles. This question had been pretty well thrashed out, and he had taken a great deal of trouble in asking makers (there are only *two*) to make candles in various ways, and he did not think many people had taken much more trouble than Mr. Harcourt in endeavouring to improve candles, but he had not only shown that candles were bad, but had gone a long way to show that it was almost impossible to improve them. It certainly was so under the present legal definition, which admitted of such considerable variations that whatever regulations might be applied it would hardly improve their position until there was a new Act of Parliament, and when they were about it, they might as well have a complete change as a partial one. That it was almost impossible to make candles satisfactory had been shown by the German Gas and Water Association, which had a special committee on the subject, and not only gave the most elaborate instructions, but actually superintended the manufacture, and sent them out, their candles being distinguished by a red thread. They had done almost everything which could be done to ensure uniformity, and besides that, they went so far as to measure the height of the flame, which was one of the greatest safeguards one could have. Still they were just in the same position as we were, and the committee had now been constituted a Committee on the Standards of Light, and had recommended that an investigation should be made by the Imperial Institute of Charlottenburg. This was stated in the report of Dr. Krüss at their last meeting.

The Chairman then proposed a hearty vote of thanks to Mr. Dibdin, which was carried unanimously, and the meeting was adjourned.

The following extract from the report of the British Association Committee on Standards of Light, describes Mr. Trueman Wood's device for fusing the platinum foil, which was shown to the meeting:—

"A strip of platinum was held between two metal clips insulated from each other. Close in front of the platinum was placed a small screen having a perforation of a quarter of an inch in diameter, through which the incandescent surface could be observed. This arrangement was placed in circuit with eight or ten cells of a secondary battery, an ammeter and an adjustable resistance being included in the circuit. It was necessary that the resistance should be capable of being taken out very slowly, so that the current might be gradually and regularly increased.

"The arrangement devised answered very well in practice. It consisted of a frame across which was stretched a series of lengths of German silver wire, some of them being straight and others coiled so as to give varying amounts of resistance in each length. By means of plugs any or all of the lengths could be put in and out at pleasure, and by this means the resistance could be roughly adjusted. The fine adjustment was given by a cross-piece working along two of the straight wires and moved by a moderately fine screw. As the cross-pieces moved along the length of the wires it, by connecting the two, brought more or less resistance into the circuit. The resistance of the whole arrangement amounted to about one ohm. It was found that with this arrangement the strip of platinum could be rapidly raised to in-

candescence, and could be kept close to the melting-point for a considerable time, a very slight increase in the current being then sufficient to cause fusion. The photometric tests made with this arrangement confirmed those which had been made when the platinum was fused by the oxyhydrogen jet; that is to say, the observations showed considerable irregularity, so much indeed that it did not seem worth while to make, as had originally been intended, a series of them, nor to construct apparatus more accurate than the first experimental one.

"A decided defect in the apparatus was the buckling of the platinum. As it was tightly gripped at each end there was no room for expansion, and before melting there was considerable expansion and consequent buckling. Had it seemed worth while to do so, it would not have been difficult to devise an apparatus by which this might be obviated, but the results were not sufficiently encouraging.

"A few photographic tests were also made by permitting the light from the incandescent platinum to fall through a screen with openings in it upon a sensitive plate, a number of exposures from different pieces of platinum being made on the same plate. These of course could only be looked upon as rough tests, but they also seemed to indicate that the amount of radiation from a given surface of platinum at the moment of fusion is not absolutely constant under the conditions we have described, and so far as they are worth anything they may be taken as confirming the conclusion obtained by the other methods."

Miscellaneous.

TOBACCO CULTIVATION IN BRITISH NORTH BORNEO.

The British Consular Agent at Sandakan, on the territories of the British North Borneo Company, in his last report says that the subject of tobacco planting has received considerable attention. For some years past the cultivation of what is known as "wrap" tobacco—tobacco combining quality with elasticity and extreme thinness, so as to enable it to cover as many cigars as possible—has been steadily increasing, and in many cases is a very lucrative enterprise in Sumatra. The value attached to this tobacco may be judged from the fact that, while the price of ordinary smoking kinds is about 5d. per pound, wholesale and in bond, "wrap" tobacco fetches from 2s. 6d. to 3s. 6d. The profits attending the cultivation are sometimes enormous. Two or three of the leading companies have been known to pay dividends of over 100 per cent.; the last dividend declared by the Arensburg Company was 152 per cent. for the year 1886. On the other hand, however, this cultivation is attended by unusual risks and by very heavy expenses. For a long time it was thought that the peculiar conjunction of soil and climate necessary for the production of "wrap" tobacco was entirely confined to Sumatra, but experiments undertaken in the first place in Sandakan Bay, and subsequently on the Island of Banguay and in Malludu Bay, demonstrate that similar tobacco can be produced in British North Borneo. Samples submitted to a tobacco conference at the Colonial and Indian Exhibition were very highly reported upon. Eager attention has been drawn to the subject; many people, principally Dutchmen, are exploring the country, and suitable land is being rapidly taken up. At the close of the year 1887 there were six tobacco estates in operation—three in Malludu Bay, one on Banguay Island, and two in Darvel Bay. Preparations are in progress for opening others, and the results of the present season are looked forward to with the greatest interest. Every tobacco estate in full work employs some hundreds of coolies. Tobacco shipped from the Ranow estate in Malludu Bay realised wholesale in Amsterdam about 2s. 11d. per pound. So far most of the capital employed, and most of the Europeans engaged on the estates now in work, as well as on those in prospect, are Dutch. This is, says Mr. Pryer, only to be expected, as hitherto the production of "wrap" tobacco has been almost entirely a Dutch industry, carried on in Dutch colonies. One of the companies, however—the Darvel Bay Tobacco Company—is English, and it remains to be seen what success will attend its efforts. One of the principal reasons which induces the Dutch to look for tobacco land outside their own colonies is the very heavy taxation they are subjected to by their own Government. In Java the planter has to pay coolie poll taxes, a license tax, high railway charges, export duties, and many other dues, besides which he has to pay yearly as large a tax upon his land as will buy it outright on a 999 years' lease in North Borneo, where also there may be said to be no taxes or imposts of any kind, except the usual ones on liquors, opium, and the like. Dutchmen, therefore, are not only prospecting the country for a tobacco land, but are considering its adaptability for sugar, coffee, and other cultivations. During the year 1887 some progress has been made in one or two other plants. Pepper has made its appearance on the export list, and the cultivation of this remunerative crop is being rapidly extended in the Bundoo district, where there is such a large infusion of Chinese blood that the people may be almost said to belong to that race. In Sandakan Bay the British North Borneo Trading and Planting Company is planting Manila hemp and pineapples, and are importing a self-feeding machine for the extraction of their fibres. The same company is also proceeding with the cultivation of Liberian coffee and pepper. Among other things which it is proposed to give attention to shortly are india-rubber and rattans. Both these plants are indigenous, growing wild in the forest, so that there is every probability of the country being suitable for their production, while, owing to their growing under

natural forest shade, their cultivation would not be attended with the expenses attending the opening and keeping up of ordinary estates. Some few hundred seedlings of Willoughbeia rubber have already been planted, with the intention that the cultivation should be largely extended if successful.

GLOVE-MAKING IN THE UNITED STATES.

The Austrian Consul-General at New York in his last report says that the places in which the manufacture of gloves is most largely engaged in, in the United States, are Gloversville and Johnstown, both situated in the neighbourhood of Albany, capital of the State of New York. The manufacture of gloves was commenced about forty years ago by a few Canadian and English women, who originally cut out and sewed the gloves themselves, and by degrees opened small factories. At first only the ordinary heavy gloves, chiefly of buckskin, were made, and it was only in 1870 and 1872 that consignments of superior gloves were received from Gloversville and Johnstown, and these only in very small quantities. At the present time there are in these two towns from 70 to 80 factories, employing together from 900 to 1,200 cutters out, and turning out annually, gloves to the value of nearly ten millions of dollars. In addition to the two towns mentioned, there exist in their neighbourhood other places which are devoted to this industry. Excluding the factories of Gloversville and Johnstown, there are no glove factories in the United States which can be compared to European manufactories. The other factories which are found in the country are exclusively engaged in the manufacture of the coarsest description of gloves, and among these there are three of some importance, two in the city of New York and one in the city of Jersey. According to the latest returns, the value of gloves manufactured in the United States amounts annually to between fifteen and eighteen millions of dollars The workpeople engaged in this industry receiving very high wages, the manufacturers find it impossible to diminish the importation of ladies' gloves, but they have, however, been able to restrict the importation of men's gloves, owing to the fact that in America better skin is used in making the latter than in Europe, while a similar skin is only used in Europe for ladies' gloves. During the fiscal year ending the 30th June 1887, the value of gloves imported into the United States amounted to 4,159,112 dollars.

PETROLEUM INDUSTRY OF CANADA.

The oil-producing territory of Canada is situated in the county of Lambton, Ontario, the greatest number of producing wells being in and about the thriving town of Petrolia, at which place the refineries are located. Consul Farrar, of Port Sarnia, Ontario, says that as far as yet developed, the paying wells are confined to a belt of land, two miles in width and sixteen miles in length, situated about sixteen miles east of Port Sarnia, and extending nearly parallel with St. Clair River. The oil territory is divided into two districts, namely, Petrolia and Oil Springs. The annual production of crude oil in Petrolia averages from 350,000 to 450,000 barrels, and the production at Oil Springs is placed at 150,000 to 200,000 barrels, making the total annual average production of crude oil 600,000 barrels for the entire region. There are nine refineries in operation at Petrolia, which, in connection with the wells and other works incident to this industry, give employment to about 3,000 men, sustaining a population of about 8,000 people. The total quantity of refined oil for illuminating purposes manufactured from the crude averages 250,000 barrels. The capital invested in the oil business is estimated at £572,000. The oil producers of Canada have been obliged to develop a high degree of ingenuity and improvement upon every plan tending to lessen the cost of sinking wells and the expense of pumping the oil. They have so far succeeded that the cost of sinking wells 475 feet, the depth required, has been reduced from £600 to £100, including casing and pump complete, and the expense of pumping from £1 to about 1s. each well per day. If such were not the case the oil industry could not be made to pay, as the great majority of wells produce only from three to ten barrels daily. The following is a description of the methods of, and appliances for, drilling and working the wells. The surface, or drift earth, is bored with an auger to the rock, which ranges from 60 feet to 150 feet from the surface, and a 10 inch wooden tube driven down to the rock. The rock is then drilled with a five-inch bore a depth of about 150 feet, and iron casing driven down. This casing is intended to shut out the surface water, which, if admitted, would prevent the free secretion of the oil, and would, by coming into contact with sulphur deposits, produce "black water," which is very injurious to the iron tubing of the pumps, and the buoyancy imparted to the tools and cable by the 300 or 400 feet of water is avoided, and the presence of oil is discovered at once by the solid tools or escaping gas. The drilling is continued until oil is struck, and the well is then ready for the pump. This is an iron tube an inch and a half in diameter, and composed of various lengths, at the end of which is the working barrel resting upon a strainer or perforated iron tube to keep out obstructions. In the working barrel are two valves, one to take in and the other to let out, and the oil passing through the strainer is lifted by the pump to the surface. In early days it was necessary to provide an engine for each well, but now, by the improved "jerker" system, one engine will drive 20 or 30 pumps, or even more than that number. A wheel or circular horizontal table is connected with the engine by the elbow joint in such a manner that it is made to perform a

quarter revolution and return to its former position. To this wheel is attached a number of "jerkers" or poles, usually made of white ash, two inches square, with iron connections, by which power is conveyed to a number of pumps extending over a large area, ond working them all simultaneously. By this plan wells that would not otherwise pay running expenses are worked at a profit. Crude oil is composed of hydrocarbons of different gravities and boiling points. In distillation these hydrocarbons separate and come off as follows:—(1) Naphtha, which is too inflammable to be used as illuminating oil, and is sold chiefly to paint manufacturers, although it is also used in other industries; (2) illuminating oil; and (3) the oils too heavy for illuminating purposes. The lightest of the latter is sold to gas works as gas oil. What remains after the parafin wax is expressed is manufactured into lubricating oil, wool oils, vaseline, hair oils, &c. Consul Farrar says that on account of the fact that thus far the refimers have not been able to remove the presence of sulphur and other impurities from Canadian oil, which causes a disagreeable odour when used for illuminating purposes, large quantities of refined oil are imported from the United States and Canada, as is shown by the fact that notwithstanding the duty of $7\frac{1}{5}$ cents. per gallon, about 200,000 barrels of oil from the United States are used annually in Canada, retailing at thirty to thirty-five cents, as against Canadian oil at fifteen to twenty cents per gallon. There are 3,200 oil wells in the districts of Petrolia and Oil Springs, and the total value of the output of petroleum and products in Canada for the year 1887 is estimated at £400,000.

ASBESTOS IN CALIFORNIA.

One of the largest and most valuable deposits of asbestos in the world, has recently been discovered in the Mojave country, not far from the line of the proposed Carson and Colorado railway between Keeler and Mojave. The mineral resources of this region have hitherto been considered worthless, except for the deposits of borax, soda, and salt. The asbestos recently discovered near Oro Grande is as fine as has been found anywhere in the world, whilst the amount of mineral in the vein far exceeds that found in any other locality. The vein is about twenty-five feet in thickness, and has been proved to extend for a distance of 1,500 feet, and is traceable for nearly three-quarters of a mile by croppings that occasionally come to the surface. Unlike many other asbestos deposits, this vein is almost unmixed with hornblende and tremolite. The fibres are long, silky, and of a beautiful pearly lustre. The fibres are tough as flax, and are capable of being spun into a fine thread. It is in short the genuine ἀμίαντος of the Greek, ἄσβεστος signifying in Greek indestructible, and ἀμίαντος unpollutable, which word gives us a hint as to the use the mineral was put by the ancient Greeks, the *amianthus* stone being woven by them into a cloth in which were enveloped human bodies that were to be cremated. And thus they preserved in the folds of the "indestructible" and "unpollutable" cloth the ashes of their dead friends, free from admixture with the cinders and ashes of the fuel used in the process of cremation. From the asbestos of Mojave might be woven similar indestructible cloth.

Besides the fine fibrous asbestos which occupies the centre of the vein, there are on the outside great bodies of what is termed "rock cork," a variety of asbestos which is as easily cut and quite as light as ordinary cork, readily floating on water; also "rock wood" and "rock-beaters," both of which are very similar to rock cork. In the same vein there appears to be an inexhaustible quantity of ordinary asbestos, such as is used for covering steam pipes, &c. The true *amianthus* is found in veins from one to four feet in thickness, and can be pulled out with the naked hands in tufts upwards of three feet in length.

Talc is also found in the same neighbourhood in immense quantities, and might be used for making fire bricks and melting pots mixed with asbestos, and no doubt when the Mojave country is opened up by the construction of the proposed Salt Lake City and Los Angeles Railway, the mineral resources of this hitherto unknown region will be fully developed.

General Notes.

BARCELONA EXHIBITION.—Information has been received from the Foreign-office, to the effect that the Exhibition was closed by Royal Commission and by the Mayor of Barcelona, on the 9th inst. A *Te Deum* was chanted in the cathedral in the morning, and the solemn act of closing was read in the afternoon, at the Palace of Fine Arts. The actual closing of the principal doors took place shortly after, in the presence of Spanish and foreign officials. The attendance of the public on this occasion was very large.

CORRECTIONS FOR MR. DEERING'S PAPER ON "EXPLOSIVES."

Page 52, col. 2, line 2 from bottom, *for* amided power, *read* amide powder.
Page 55, col. 2, line 24, *for* 10 HO_2, *read* 10 H_2O.
Page 56, col. 1, line 28, *for* NO_4, *read* N_2O_4.
———— line 35, *for* $Pb(N_2O_3)_2$ *read* $Pb(NO_3)_2$
Page 57, col. 2, line 31, *for* ammonia nitrate, *read* ammonium nitrate.
Page 59, col. 2, line 23, *for* cartridge, *read* cartridge of dynamite.
Page 60, col. 1, line 7 from bottom, *for* NH, *read* NH_3
Page 61, col. 1, line 33, *for* 35 lb., *read* 3 lb.

Journal of the Society of Arts.

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FRIDAY, DECEMBER 28, 1888.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

JUVENILE LECTURES.

All the tickets for these lectures having now been disposed of, the issue is stopped. As all the available accommodation will be required for those members who have applied for tickets, it will be understood that no member can be admitted without a ticket.

PRIZES FOR ART-WORKMEN.

Prizes are offered to Art-workmen in the following classes:—

I.—Pottery (including Porcelain and Earthenware).

1. The Body, any material.
   a. Thrown, not shaved, first prize, £5; second prize, £2.
   b. Shaved or turned, first prize, £5; second prize, £2.
2. Decoration.
   a. Modelled and glazed, first prize, £10; second prize, £5; third prize, £3.
   b. Painted under glaze, first prize, £10; second prize, £5; third prize, £3.
   c. Enamel on the glaze, first prize, £10, second prize, £5; third prize, £3.
3. Stone salt-glazed ware.
   a. Plain; incised and glazed, first prize, £10; second prize, £3; third prize, £3.
   b. Coloured or otherwise decorated, first prize, £10; second prize, £3; third prize, £3.

The Art-workman must have designed the body of the pot as well as have executed the decoration.

All the specimens of pottery sent in for competition must be dated on the clay.

II.—Stone Carving.

First prize, £25; second prize, £15; third prize, £10; fourth prize, £5.

The capital of a column, with square, circular, or octagonal abacus, not to exceed twelve inches in width.

III.—Wrought-Iron Grilles.

First prize, £25; second prize, £15; third prize, £5.

A grille measuring not less than three feet superficial, nor more than five feet superficial.

The object for which the grille is intended must be stated—whether for a protective purpose, for the outside of a window, for a street-door panel, or for indoor use as a window screen, coil case, ventilator, &c.

IV.—Goldsmiths' and Silversmiths' Work.

[Prizes presented by the Goldsmiths' Company.]

A cup or sugar basin of beaten silver, chased or otherwise, made within the year 1888. First prize, £20; second prize, £5.

A pendant or brooch, or locket of gold without gems. First prize, £20; second prize, £5.

All articles for competition must be sent in to the Society's House on or before Tuesday, April 23rd, 1889.

The conditions under which these prizes are offered have appeared in previous numbers of the *Journal*.* They can also be obtained on application to the Secretary.

LIST OF MEMBERS.

The new edition of the List of Members of the Society is now ready, and can be obtained by members on application to the Secretary.

COVERS FOR JOURNAL.

For the convenience of members wishing to bind their volumes of the *Journal*, cloth covers will be supplied post free for 1s. 6d. each, on application to the Secretary.

* See *Journal*, June 15.

Proceedings of the Society.

CANTOR LECTURES.

LIGHT AND COLOUR.

BY CAPTAIN W. DE W. ABNEY, C.B., F.R.S.

Lecture I.—Delivered November 26, 1888.

I hold in my hand a series of colours of various hues and depths, some of them are fugitive and others are fast colours, and it is the object of the lectures I have been called upon to deliver to answer the questions as to what causes the colours, and what causes the fading of some by light. In four lectures this subject can by no means be treated exhaustively, and I can only endeavour to explain, in as familiar language as I can command, and by some plain experiments, what I desire to enforce upon your minds. A great deal has been written in the last two years on the subject of the fading of water-colours, and from what I have gathered from the newspaper correspondence, it is not quite unnecessary that a few familiar discourses on the subject should be given, to prevent a repetition at all events of some of the blunders that have been made in physical phenomena. It may be known to some who are present here to-night that Dr. Russell and myself have carried on a series of experiments during two years on the subject of the fading of water-colours, and as our report to the Science and Art Department, which was presented to Parliament, pleases neither the party who cry out that water-colours are stable, nor yet the party who proclaim the contrary, we may presume that our results are not altogether wrong. To these experiments I shall refer later in the course of lectures.

Now, to commence with the elements of colour from the physicist's point of view. I wish to show you that the colour of an object depends on the composition of the light falling on it, on the material on which such light falls, and on the eye of the person. The screen which I have here is what we call white, when viewed by ordinary daylight or artificial light, and such a screen not only will reflect white light, but also all coloured lights with the greatest brilliancy possible.

Let me throw a spectrum on the screen to serve as a text. If a brilliant spectrum be looked at, we see that it is really divided into three colours, blue, green, and red, with shades of other colours blending these colours into one another. I am not going into the theory of the matter, but I would ask you to remember that the mean red light has a wave length of about 38,000 to the inch, the waves being in the luminiferous ether of whose existence we only know by circumstantial evidence, the green of about 50,000 to the inch, and the violet of about 64,000 to the inch. The other colours have intermediate wave lengths.

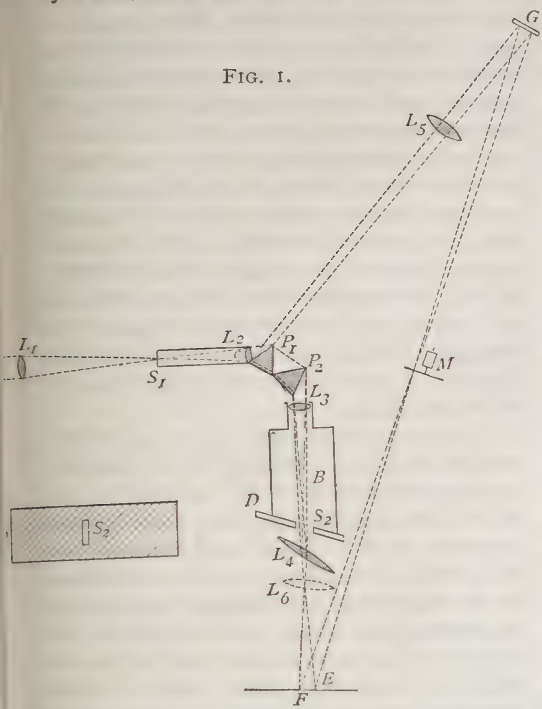
I would remind you of the old experiment that red, green, and blue, when combined together by means of rotation, give a grey light which can be matched by a combination of black and white. Here we have such a combination forming a grey in the electric light. The reason assigned for this is, that in the eye there are three sets of nerves, one which responds to the red, one to the green, and the other set to the blue. When the disc is at rest, an image of these three coloured sectors is formed on the retina, and the nerves lying at the parts of the retina on which the image falls respond to these colours, and we see the sectors coloured. If there is astigmatism, or defects in the optical apparatus of the eye, the image is not sharp, then we have an image of part of the two colours adjacent blended into one another, or again if the discs rotate rapidly, so that the same part of the retina receives the coloured images in quick succession, all three sets of nerves are brought into use, and we have an impression of white, or rather grey, produced. But this subject I shall allude to again in one of my subsequent lectures.

We can recombine also the pure colours of the spectrum by several plans, the simplest to my prejudiced mind being that which I introduced. I take away the long focussed lens, and put a shorter focussed lens in its place attached to a camera, for reasons which I will shortly explain (Fig. 1, p. 81).

On a collimator, G, to which is attached the usual slit, is thrown, by means of a condensing lens, a beam of light, which emanates from the intensely white-hot carbon positive pole of the electric light. The collimating lens, L_2, is filled by this beam, and the rays issue parallel to one another and fall on the prisms, P_1 and P_2, which disperses them. The dispersed beam falls on an ordinary camera lens, L_3, of slightly larger diameter than the height of the prisms, and a spectrum is formed on the focussing-screen, D, of a camera. When the focussing-screen is withdrawn, the rays would form a confused patch of pink-coloured light on a

white screen, F, placed some four feet off the camera. The rays, however, can be collected by a lens, L_4, of about two feet focus, placed

FIG. 1.



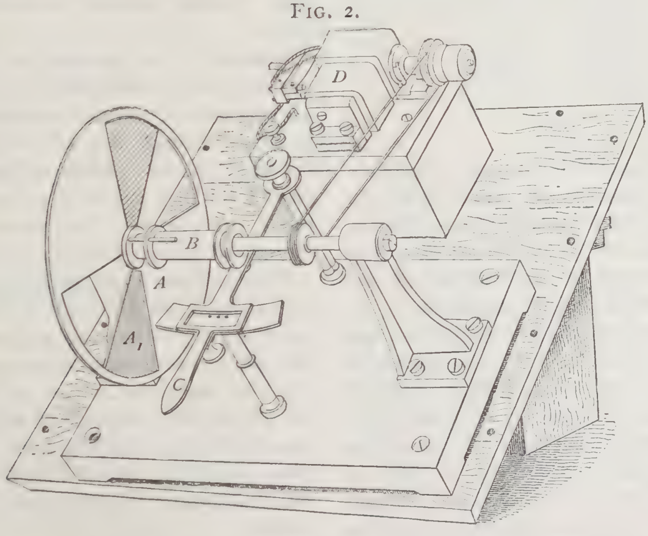
near the position of the focussing-screen, and slightly askew. This forms an image on the screen of the near surface of the last prism, P_2; and if correctly adjusted, the patch of light should be pure and without any fringes of colour. The card, D, is a strip which fits into the aperture left for the focussing-screen in the camera. In it will be seen a slit, S_2, the utility of which will be explained later on.

It often happens that a second patch of white light, comparable to that formed, is required. Advantage is taken of the fact that from the first surface of the first prism P_1, a certain amount of light is reflected. Placing a lens. L_5, in the path of this reflected beam, and a mirror, G, another square patch of light can be thrown on the same screen as that on which the first is thrown, and this second patch may be made of the same size as the first patch if the lens K be of suitable focus, and it can be superposed over the first patch if required.

We have now a square white patch upon the screen, from the re-combination of the spectrum. If I wish to diminish the brightness of this patch, there are at least two ways in which I can accomplish it. First, by closing the slit of the collimator, and, second, by the introduction of rotating sectors, M, which can be opened and closed at pleasure during rotation in the path of the beam.

The annexed figure (Fig. 2) is a bird's-eye view of the instrument. A A are two sectors, one of which is capable of closing the open aperture by means of a lever arrangement, C,

FIG. 2.



which moves a sleeve in which is fixed a pin working in a screw groove; D is an electromotor causing the sectors to rotate, and the aperture in the sectors can be opened and closed at pleasure during their revolution. To show you its efficiency, if I place two strips of paper, one black and the other white, on the screen, and cast a shadow from a rod, R,

by the direct white light on the white strip, and a shadow from the same rod by the reflected light on the black strip of paper, and interpose the rotating sectors in the path of the reflected light, the aperture of the sectors can be closed till the white paper appears absolutely blacker than the black paper. White thus becomes darker than lamp-black, owing to want of illumination on the former.

We all talk about white light; we say that the electric light is white and that gas light is white. I wish to show you that the whiteness is a mere matter of judgment.

I throw the shadow, by the electric light, of a thick rod on white paper, and another shadow by gas light, on the same paper, and we at once see that the shadow illuminated by the electric light seems blue, whilst that illuminated by the gas light appears orange, yet we speak of both gas light and the electric light as white lights. Evidently, if these two differ so much in colour, pigments will take different hues when illuminated by them. Putting paper coloured with red, blue, and green pigments in the shadows, the change in hue is at once apparent. Placing in the shadow illuminated by the electric light a strip of paper coloured orange (Fig. 3), by orange chrome and

FIG. 3.

aureolin, we see that now the electric light reflected from it appears of very nearly the same hue as the light from the gas reflected from white paper. Gas light, we may say then, is orange rather than white, if we take the electric light as the standard.

We have seen that colours appear of different hue in the electric light to that which they appear in gas light, and I wish to enforce this more strongly upon you by an experiment which I introduced a year ago. In front of the condenser of the electric light lamp I place a circular aperture some inch in diameter, and by means of a lens throw an image of it on a white screen. We may suppose this to represent the sun, the colour of the light being very much the same as that which it has in England about midday in the middle of May. In front of the aperture I place a trough containing a solution of hyposulphite of soda, and then drop into it dilute hydrochloric acid, and stirring up the two together very fine particles of sulphur slowly separate, and the white light, owing to the law of scattering by small particles, loses some of its components, and we have a gradual reddening of the sun—first yellow, then orange, and finally a red—the series forming a very exact representation of the colours of a setting sun. If we place coloured pigments in this changing light, we see how, towards sunset, the blues become darker whilst the red change but little in hue. It may have been remarked that in an evening the last colours in a picture to disappear are the reds. The colour of sunset light now imitated before you gives a clue to the reason of this.

We may as well trace the cause of this change in colour. Placing a cell containing hyposulphite of soda in front of the slit of the spectroscope, and throwing the spectrum on the screen, and then adding the dilute hydrochloric acid, we find that as the light from the reflected beam (which we throw just above the spectrum) becomes yellow, orange, and then red, so the spectrum loses the violet, then the blue, then the green, till finally the red alone remain.

Let me further exemplify that you cannot know what effect the colour of the light has upon a colour unless you know its composition.

The slit S_2 in the card D (Fig. 1) can be passed through the spectrum, and as it cuts off all the colours of the spectrum, except that passing through the slit, we have different coloured square patches of light thrown by—what I will now call—our patch-forming apparatus, the colour of the patch being that of the colour issuing through the slit.

Now sodium, when ignited, gives a peculiar yellow light, due to a line in the orange. If I send the light from this sodium line through the slit S_2, we have a square patch of sodium light on the screen. The rod casts a shadow as before, but instead of casting a second shadow by the reflected beam, I cast a shadow from gas light, when it will be seen that the two illuminated shadows have almost the same colour.

I now shall perform a common Christmas experiment, and ignite some spirits of wine in which salt has been dissolved, and illuminate with that light cards on which various blue, red, green, and yellow pigments have been placed,

and we see that all the pigments partake of various shades of orange, instead of the colours seen by gas light. The reason of this is apparent; in gas light we have all rays present, in the sodium light there is only orange present. We shall see that as the colour of a blue pigment depends principally on the reflection of blue rays, that of a green of the green rays, and so on, it is only to be expected that the colours of pigments, when illuminated by pure orange light alone, will only give different shades of orange.

This shows also that light or colour may to the eye appear to be the same and yet be very different in optical composition. I cast two shadows of the rod in the patch-forming apparatus, one by the recombined spectrum and the other by the reflected beam, and pass the card, D, with the slit, S^2, in it along the spectrum. One shadow will be illuminated by the white light and the other by the light from the parts of the spectrum coming through the slit S_2. If I place emerald green in the shadow illuminated by white light, I find that there is one point in the green of the spectrum which matches it in hue, and I can make them of the same depth of colour by the introduction of the rotating sectors. Evidently, then, the coloured light of this part of the spectrum and that of the emerald green might be mistaken for one another, and so with other colours. There are some pigments, however, which cannot be matched by the spectrum colours.

That emerald green is a combination of colours I will at once show you. A strip of card is placed in the spectrum, on one half of which is this pigment. Half of the breadth of the spectrum falls on the white card and half on the pigmented card. It will be

FIG. 4.

seen that the emerald green reflects other colours of the spectrum besides that which it matched in the colour patch-forming apparatus. The combination of all these other colours in the proportions reflected from the pigment, form the colour which, in the simple colour of the spectrum, we should call emerald green. So if we pass other pigments through the spectrum we get similar results, though not all pigments can be so matched.

Miscellaneous.

BRUSSELS INDUSTRIAL SCHOOL.

The Ecole Industrielle of the Brussels Municipality, assisted by Subventions from the Belgian Government and the Province of Brabant, now occupies the upper floor of the Palais du Midi, where was held the International Exhibition of 1880, and is under the management of M. Jules Defontaine, who received the diploma of Ingénieur des Mines from the Mons School of Mines. The yearly budget amounts to 112,000 frs., or £4,480, and the number of pupils varies from 500 to 600.

The Director himself gives a course of thirty lectures each on mechanics and prime movers; and M. Paul Davreux, Assistant Inspector of Industrial Schools, a course of fifty lectures on physical science. There is a workshop provided with machine tools, driven by a gas-engine in charge of a mechanic, for workshop practice. There are classes of freehand and machine drawing, and also one on architectural drawing, with the elements of civil construction, held on Sunday mornings, which are the best attended of all. In the class of machine drawing, conducted by M. Pierry, the pupils sketch the various parts, and then draw them from their sketches; and in that of descriptive geometry and freehand drawing, with the elements of perspective, they are made to sketch geometrical forms, with sections at various points, with special reference to roofs and stone-cutting. There is already a good collection of physical apparatus and models, used in the Course of Physical Science, and also a very complete mineralogical collection. Attendance at the Course of Industrial or Political Economy is made compulsory on the pupils of other classes, in order to counteract the socialist movement.

There is a course of chemistry extending over three years, and a roomy laboratory has lately been fitted up in a most complete manner. Anyone, on giving proof of sufficient chemical knowledge, may use the laboratory and apparatus gratuitously, and may even call upon the lecturer for advice and assistance. Adjoining is the chemical laboratory of the municipality, where articles of food taken to the Police-office at the Hotel de Ville, are analysed gratuitously. There is a course of twelve lectures on photography, as well as practical instruction in all branches of the art, including the reproduction of drawings. There is also a course on the application of electrical science, given by M. Boulvin, a gas motor, dynamo, &c., serving for demonstrations in electric lighting.

Thirty lectures on elementary notions of hygiene, considered specially from an industrial standpoint, are given by M. Max, and great attention is paid to the lavatories and sanitary arrangements, which, although under cover, are open to the atmosphere.

The remaining classes are in arithmetic, book-keeping, elementary algebra, and plane geometry applied to industrial purposes, surveying and levelling. There is a good technical library, containing standard works in various languages, English, French, Belgian, German and Spanish patents, the former from their first issue, in 1617, and also a reading-room, frequented by six to seven thousand readers yearly, provided with the leading technical journals of Europe.

All the classes are held in the evening, except those of architecture, civil construction, hygiene and political economy on Sunday mornings. The whole course of instruction extends over three years, and is chiefly intended for workmen and foremen. Pupils, who must be fourteen years of age, and already possess an elementary education, may either follow the whole programme, in which case they may qualify for certificates as draughtsman, electrician, analytical chemist and clerk of works, or they may attend any particular class. The fees for the whole evening course of 150 lessons, is 40 fr. (28s.) and for any separate course at the rate of 30 c., or 3d. per lesson. Exemption from payment may be obtained on good grounds: and there are exhibitions for travelling. Various prizes, including a Savings' Bank deposit, are granted for proficiency on examination, the examiners being appointed by the Administrative Council, presided over by the Echevin or Alderman of Public Instruction of the Brussels Municipality. Besides its own courses, the Ecole Industrielle affords accommodation to technical schools established by Syndicates or Chambres de Commerce. There is thus a class of typography in full working order; and one in tailoring is about to be established. A successful class in watchmaking, as to which mention has already been made in the *Journal*, has lately been removed to independent premises.

BUTTER AND MARGARINE IN ITALY.

The French Consul at Milan, in a recent report on the production of butter and margarine in Italy, quoted in the *Board of Trade Journal*, says:—

"In Italy butter is only produced in four districts; in the plains between the Alps and the Po, in the Tyrol, in the districts of Reggio, Emilia, and Sorrento. The best qualities come from Lombardy, and the privilege of regulating the prices is reserved to the Milan market; the butters of Reggio and the Tyrol are used principally for mixtures, their immediate consumption being very moderate; as regards the products of Sorrento, unimportant in quantity, they are disposed of on the Naples exchange.

"The other Italian provinces are not employed in the manufacture of pure butter, which they only consume to a very small extent, and for which they substitute oil for all daily wants. Sicily and the province of Naples use fat of American origin and substitutes coming from Marseilles; butter there is furnished by the Lombardy markets, and passes as a luxury.

"At the present time England, Germany, and even Russia place upon the world's market pure butter of their own production, and Germany is especially devoted to this industry, to which it has given a decided impetus; as a result there has been an increase of production which has benefited quantity at the expense of quality, the question of economy having naturally overcome the greater part of the consumers.

"Italy has followed the general advance, but the pasturages and, consequently, the milks vary so much in quality that it would be better to confine oneself to one type of butter, that of Milan. The adulteration of Italian butters, which have not escaped Italian trade, has not, however, checked its export, as is shown by the following table:—

——	Imports.	Exports.
	Quintals.	Quintals.
1867	667	1,969
1872	2,798	5,271
1877	1,535	12,734
1882	1,408	21,685
1885 (fresh butter)	2,665	16,358
1885 (salt butter)	23	15,787

"The 2,665 quintals at the average price of 260 lire comes to 692,000 lire; the 23 quintals at the rate of 255 lire represent 5,865 lire; the 16,358 quintals at the rate of 260 lire amount to 4,253,080 lire; the 15,787 quintals at the rate of 255 lire represent 4,025,685 lire.

"France figures in the imports of fresh butters at 1,105 quintals, Austria at 1,544 quintals. Of the exports of fresh butter France takes 12,932 quintals; Austria comes next with 969 quintals. Of the exports of salt butter France takes 7,535 quintals; then comes British India for 2,759 quintals, nnd Germany for 2,004 quintals.

"This table shows that the Italian exports, which in 1867 amounted to 1,969 quintals, reached 12,734 quintals in 1877, increasing in 1885, under a double form, to 32,145 quintals, Paris being the principal outlet with Central France, London, Amsterdam, Hamburg, the English possessions in India, Egypt, and America.

"Numerous trials have been made to obtain on foreign markets the classification of Italian butters, but every effort has been frustrated by the fact of the great difference existing between the Milan butter (Lombardy products) and the qualities of other Italian provinces, the markets of the Peninsula finding it difficult to make a specialty of a single type, and the natural proof of this Italian inferiority exception being made of the Milan type, is still further confirmed by the average price of the last ten years on foreign markets.

"It should be borne in mind that the principal obstacle to the development of the trade in pure butter arises from the increasing use of fats and lards imported from America at very low prices, and of artificial butters made in France, Germany, England, and the Netherlands, in which the exact proportion of pure butter is very questionable.

"The demand for butters in Europe, South America, Australia, India, Japan, and even China, has become so important that in presence of the insufficiency of the natural product it became necessary to manufacture an analogous substance, so that in Holland and Denmark, the principal countries producing pure butter, the artificial butter industry was undertaken without fear of prejudicing the pure article. It was not long before Italy followed the example of these two countries, but the first attempts were not fortunate.

"MM. F. Chierichetti and Segondi, of Milan, have manufactured margarine butter on the patented Galli system; in 1880 this house established branches at Rifredi, near Florence, and at Rome, and at the present time it represents the single Italian establishment of this kind, the Carlo Verati house, which carried on a similar manufacture, not having been able to withstand French competition. This keen competition of which Italy complains is carried on by a Marseilles house, whose artificial butters are specially prized, and which, notwithstanding the expenses of transport, Customs, &c., estimated at 20 francs per 100 kilogrammes, nevertheless succeeds in disposing of about 150,000 kilogrammes of it in Italy per annum, at prices, excluding packing and other charges, varying according to the prices of pure butters and of fats, between 120 and 130 francs per 100 kilogrammes, in summer, increasing in winter to 150 and 160 francs. It should be observed that these butters, according to the tariff resulting from the treaty of commerce in force up to the 31st December, 1887, only paid 5 francs per 100 kilogrammes, whilst according to the new general tariff, the duties of which have been applied from the 1st January, 1888, they pay 12·50 francs.

"Italy, compared with a number of European countries, is in an inferior position as regards the production of pure and artificial butters, its production of pure butters being of relatively insignificant importance and of a generally less marketable quality than that of the neighbouring countries; the average prices of pure butter in Italy have been: 2·64 lire per kilogramme in 1874-75; 2·51 lire per kilogramme in 1887-78; 2·69 lire per kilogramme in 1880-81; 2·61 lire per kilogramme in 1883-84; 2·42 lire in 1884-85; 2·30 lire in 1885-86; 2·23 lire in 1886-87.

"Italy claims for its margarine a superiority which I do not hold to be justified, knowing the keen competition carried on, even on the Milan market, with Marseilles imports; the superiority of the Marseilles production arises from the process of manufacture which, while not requiring the use of milk, facilitates the preservation of the substance without taste or smell.

"It is estimated that Italian margarine butter costs at the present time from 40 to 45 per cent. less than pure butter, offering, besides, the advantage of being much more easily handled."

THE MINING INDUSTRIES OF THE FRENCH POSSESSIONS.

New Caledonia contains numerous beds of gold, silver, copper, iron, nickel, cobalt, lead, and coal, which were only discovered some years after the French obtained possession of the island in 1853. Returns which have been recently prepared by the French Government have traced the history of these discoveries, and of the development of the mineral wealth of the island. It appears from the *Statistique de l'Industrie Minerale* that the presence of nickel was discovered for the first time in 1867, but it was only in 1874 that it was found in sufficient quantity to enable it to be profitably worked, at Mont d'Or, near Noumea, and at Canala on the East Coast. The first workings of any importance were commenced in 1876, and were carried on at Houïlou, at Canala, Nakety, Poro, and principally at Thio, and in a short space of time the whole of these undertakings were concentrated in the hands of the Société de Nickel, which, in 1882, devoted its attention chiefly to Thio, and succeeded in developing it to a remarkable extent. Besides these workings others were commenced in 1883, one of the most important of which was at Kua, but the excessive development of the production of nickel ended in a crisis in 1885; the furnaces at Noumea were put out, and the workings were considerably restricted, and even at the present time they are almost suspended at Thio and Kua. The soil in New Caledonia appears to be extraordinarily rich in nickel ores, and it is stated that the ore found in this island are superior to any other, being entirely free from sulphur and arsenic. Already more than 30,000 tons have been thrown upon the market, and in addition to this there remain in the old workings of the mines an equal quantity of ore, which was at first considered to be valueless, but which recent analyses have shown to possess metal in the proportion of from 3 to 11 per cent. The presence of cobalt was only discovered towards the year 1876; the first beds were worked at the South Bay, and towards the west of the island, and later, about the year 1882, workings were commenced at Goro, Unnia, Port Bouquet, Nakety, Canala, Monéo, Mou, Yandè island, and the Belep Islands. It was in the furnaces of Noumea that the first cobalt ore was smelted, and although the Caledonian ores are comparatively poor, they are considered to be remarkably pure. The cobalt mines, like those of nickel, are lying idle through overproduction, and, equally with the latter, are in a position to furnish large

quantities of ore when occasion requires it. Copper was first found in the year 1872 in the bed of the Onégoa river, and in the following year it commenced to attract considerable attention and capital, with the result that an important industry soon sprang up, and the workings have been continued without interruption until the year 1884. In this year, however, the works were stopped after having turned out more than 40,000 tons of ore. Other mines exist round the Balade and in the valley of the Diabol, but they have never been properly worked, and although the copper industry of New Caledonia has not, up to the present, been a great source of wealth, owing, in some degree, to the serious fall in the prices of this metal during the years 1882, 1883, and 1884, the discovery of new mines on the left bank of the Diabol is confidently expected to add very materially to the importance and wealth of the colony. Chrome is abundant in many parts of the island, and it was first traced in 1865, but it was not until very much later that it commenced to attract any serious attention, owing to the discovery of fresh mines at Plum, to the south of Mont d'Or. This mine was worked from 1878 until 1883, and produced from 10,000 to 12,000 tons. Other chromo mines were worked in addition to those at Plum, at South Bay, Unnia, Port Bouquet, &c., and there has been great activity at these mines during the last three years, but they have recently been abandoned, and the Plum workings are the only ones that are now being carried on.

There is no very large production of antimony, only about 880 tons being turned out in 1884. Gold was met with for the first time in 1863, towards the north-east of the great chain of micaceous schist which skirts the coast towards Pouébo, but in such small quantities that it was not then considered to be of sufficient importance to commence working. In 1870, however, a considerable quantity of the precious metal was found at Fern Hill, and the workings were speedily begun. The ore extracted was treated near the borders of the Diahot, and produced in ten years an amount valued at 500,000 francs. The hopeful views, however, taken by mining speculators of these gold mines have not been realised, as in 1873 the veins at Fern Hill commenced to show signs of exhaustion, and the workings were suspended. During the last few years, however, renewed attempts have demonstrated the possibility of discovering fresh rich zones, and gold continues to attract considerable attention in the colony. Fresh traces of very fine gold have recently been found in the valley of the Diahot and near Niambi. Lead and silver were first discovered in 1884, and it is stated that investigations have led to the belief that the colony will eventually benefit very greatly by these discoveries. In the year 1865 coal was first sought for in the valley of the Dumbéa, and when certain public works in connection with the construction of the road from Ourail to Canala were commenced, the existence of some remarkable veins of coal was disclosed, some of which are said to have exceeded six mètres in thickness. The result of these discoveries was the appointment of a commission to inquire into the coal fields of the colony, and they commenced their labours about the year 1885. The coal fields of Mont d'Or, St. Louis, Noumea, Tonghoné, Dumbéa, and Paita were successively visited and reported upon, and mining operations were commenced at Portes-de-Fer in Noumea, and in the basin of the Moindon. Beyond the limits of the recognised coal region new fields have recently been discovered at Voh and in the valley of the Néhoué.

As regards the other French colonial possessions, French Guiana appears to be the only one in which the mining industries have attained any considerable importance. In the year 1884 the quantity of gold found there amounted to 1,953 kilogrammes, representing a value of about 5,000,000 francs. It appears from the official returns that no coal fields exist in the regency of Tunis, and in the year 1885, which appears to be the latest for which official returns are available, no mining concessions were granted. Of the seven existing iron mine concessions, which were made before the year 1885, three belong to the *Comité d'Etudes* of Tabarka and four to the Mokta-el-Hadid Company. One of the conditions of these concessions was that each company should construct a railway and a port, but this has not in either case been fulfilled, owing partly to the crisis from which the mining industry has been suffering, and partly to the low prices of iron ore. Concessions were granted for two lead mines, one to the Bône-Guelma Company, and the other to the Italian Metallurgical Society, both of which, however, have been productive of no results, and even the Djebba mine, although only thirty kilometres distant from the railway from Tunis to Ghardimaon, could not be worked in 1885 owing to excessive cost of transport, and to the depreciation in the prices of lead, while the important mine at Djebel Reças has also remained practically untouched, although it is stated that workings are shortly to be commenced on a very extensive scale. Owing to the non-existence of coal mines, all mineral fuel required for the Regency is derived from abroad. The principal consumers are the two railway companies and the Tunis Gas Company, which burn English coal, while that consumed for private enterprise is chiefly brought from England and Belgium. Tunis possesses neither salt marshes nor beds of rock salt, and all the salt consumed is obtained from the saline lakes, or *sebkra*, the value of which is estimated to be about 38,800 francs. The only works that exist in the country are those for the treatment of galena. One situated at Djebba has been completely abandoned, while the other, which was established on a large scale at Djebel Reças was originally intended for the treatment of the ores extracted from the Mornack mines by the ancients, either the Romans or the Carthaginians. It is now utilised for the treatment

of the galena obtained from the Djebel Reças mines, the production of which did not in 1885 exceed 92 tons.

THE VITALITY OF SEEDS.

Mr. John Philipson read a paper lately before the Newcastle Society of Antiquaries, on "The Vitality of Seeds found in the Wrappings of Egyptian Mummies," from which the following notes are abstracted :—"The two problems that presented themselves were—1. Would seeds retain their germinating powers during a period of 2,000 or 3,000 years? 2. Have plants ever been raised from such seeds? The whole matter turns upon the character of the seeds which have been discovered in the folds of mummy wrappings. I have ample proof that plants have been raised from such seeds, not only in the south of England, but in this neighbourhood, and it only remains for the spurious or genuine nature of these seeds to be decided to set the matter at rest. Experiments without end have been made to show for what length of time seeds will retain their vitality; but the trials made under the auspices of the British Association by the late Mr. Strickland, Professor Henslow, Dr. Lindley, and Dr. Daubeny, were so extensive, and were conducted with such care, that they overshadow in importance all experiments of a like nature. I find, however, that there are authorities who are extremely reluctant to accept as final the evidence furnished by these trials, as so many instances are on record to prove that seeds will retain their vitality for very much longer periods than would appear to be the case from the British Association's experiments, which commenced in 1834, and lasted more than twenty years. In saying so I do not refer to seeds which may have retained their vitality for thousands of years, but to cases where they have undoubtedly done so for more than a century. The British Association's experiments extended to 288 genera and 71 natural families, including nearly all the kinds of vegetables cultivated for culinary and other domestic purposes. One hundred seeds of each kind were in general sown. If any of these germinated, a smaller number of the same were experimented upon again after a lapse of five years and so on, as long as any came up. In this way it was found that the greater number of species had lost their vitality after ten years, 20 species, or about one-fourth after 20 years, but that the only species that reached 25, 26, or 27 years belonged to the natural families, leguminosæ, malvaceæ, and tiliaceæ. The conditions under which the seeds of mummy-wheat have been found are in the highest degree favourable to the preservation of the dormant state, a perfectly hermetical exclusion from the action of the oxygen of the air, and from moisture in a climate the aridity of which is well known must have conduced to the preservation of the vital powers of seeds, which, though having the life-germ very close to the surface, and but thinly protected, are known to yield an extremely hardy plant, whose vitality is not easily destroyed. I have endeavoured to show that although seeds are not easily preserved in a living state for a great number of years, there are what Professor Henslow calls 'remarkable exceptions' where they have lain unharmed for centuries. Egyptain monuments admirably fulfil the conditions necessary to preservation as in a sarcophagus, or hermetically sealed vase, they would be protected from the air and from variations of temperature or humidity. I now propose to deal with some cases which in my opinion, prove that such exceptions have appeared more than once with seeds taken from mummy wrappings, and by persons in this country. These seeds have yielded what has long been known as 'mummy wheat,' a plant having a compound spike, a distinguishing characteristic by which it is readily known, but which is not altogether permanent, ears averaging 7″ in length and from 15 to 20 on each root." After giving a large number of instances of the affirmed vitality of mummy wheat, Mr. Philipson sums up the result of his investigation, as follows:—"I have now placed before the meeting the evidence, which by some considerable labour I have collected, and to the best of my ability investigated. It may be argued that the agreement, although strong, does not amount to a demonstration, and I admit that there is a strong array of opinion against me, but it is opinion only; and, although men may agree, they may be agreed in error."

FOREST PRODUCTS OF SIAM.

The products of the forest, second in importance among the resources of Siam, number many valuable woods, some of which are unknown to western nations. Sapan is largely exported to China and Hong Kong. Ebony, rose padoo, yellow and satin woods, are susceptible of a high polish, and are much used for making furniture and fancy articles Iron wood is employed in building the small native craft, and for that purpose is said not to be excelled Agilla or calambac, found in the hollow trunks of trees, is highly aromatic, and is used by the natives of Asia for burning as incense. The United States Consul at Bangkok says in his last report that fine specimens of agilla, heavily impregnated with its essential oil, command fabulous prices. It is also used in medicine. Many of the choicest productions of the country can only be obtained in small quantities, and except in the King's palace or among the higher nobility they are seldom seen; they are used principally in the construction of musical instruments. Teak is the most valuable timber of the country. It is utilised in immense quantities throughout the East for house building. It is largely exported to China and to Europe for ship building purposes, and

it is said to be unsurpassed for resisting the ravages of the white ants, and the effects of the weather. It grows in the northern part of Siam and Burmah at an altitude of from 1.200 feet above the sea, and reaches its greatest perfection in about one hundred and twenty years. Ten or fifteen years make a good sized tree that can be cut down where quality of wood is not an object. It is generally believed that the forests will become exhausted before many years, there being no laws to prevent the indiscriminate felling of timber, nor to render compulsory the planting of new trees. The teak district is from 100 to 150 miles in width, the forest being in charge of the governors of the provinces in which they are situated. They are generally leased for a term of ten years, and the lessee is obliged to fell and remove the greatest number of logs possible, he paying a royalty to the governor of about seven shillings and sixpence. The trees are girdled, and are left standing for two years to allow the sap to run out, and the wood to become perfectly dry. If girdled to the heart, and deep holes are bored with an auger, one year will be sufficient. The cutting down takes place in the dry season, and the logs are eft until sufficient rain has fallen to allow of their being dragged to the river with the help of elephants. The logs are collected into rafts preparatory to being floated down to Bangkok. For convenience in trading in timber, a fixed rate has been established by the foresters to be used as a unit in computing the value of of logs. After the logs are made up into rafts, they are delivered to the raftsmen to convey to Bangkok. They charge about one-half of the unit of value, and bind themselves to deliver, within a certain time, the number of logs mentioned in a document drawn up by the authorities, of the sizes specified therein. When all is ready, the evil spirits of the river must be propitiated, which causes an outlay of about fifteen shillings for offerings, and is paid by the owner of the timber. This custom remains in force, despite the efforts of the foreign and educated classes to stop it, and should anyone ignore it they would be unable to procure raftsmen. In years of light rainfall, great difficulty is experienced in getting timber to market. The year 1886 was the first year that timber has been floated down in any quantity since 1884. There is one steam saw-mill in Bangkok belonging to foreigners, and six where coolie hand-labour is employed. The Chinese have nearly a hundred establishments, many of which saw under agreement with foreigners. Square timber sold in 1887 at about three shillings and fourpence the cubic foot, and plank at about three shillings and sixpence. For shipment to Hong Kong, timber sold for twenty-five shillings per yoke of 169 square feet for prime, and seventeen shillings and sixpence for, second-class wood. From the trade returns of Siam it appears that the exports of teak to all parts in 1886 amounted to 365,349 piculs, valued at £140,000, as compared with 304,762 piculs in 1885, valued at £135,352. Of the shipments of 1886, about 45 per cent. went to Europe, and there was a marked increase to all parts with the exception of Bombay. Of the products of the forests other than teak, the value of the shipments in 1886 amounted to £67,000, against £47,000 in 1885, an increase of about 20 per cent. Agilla, rose, padoo, and yellow woods, also showed an increase, while the exports of sapan, ebony, mangrove bark, and Krangi wood decreased.

General Notes.

Phosphate. — The quantity of phosphate produced in Canada has gone on increasing, having doubled in the last ten years. The greater part is mined in the Quebec district. Eleven provinces in the Ottawa district employ 456 men, and five provinces in Ontario employ 130 men, but in some cases the men are not employed all the year. The export n 1887, was 23,152 tons valued at £89,000. Nearly all is sent to Great Britain and Germany.

Lithographic Stone in Canada.—The stones of the townships of Mador and Mamon, and of the counties of Peterboro' and Bruce, have been examined and practically tested by lithographers, and in several cases pronounced to be of good quality; they have also obtained medals at various exhibitions. They were obtained from the surface in small quarries, and possibly when the quarries are more developed, better stones, free from "sparks" of quartz or calcite, will be available in large slabs. It is a well-known fact that the Bavarian quarries do not produce now sufficient quantity of the best quality stones for the requirements of the American market, and this should lead to the development of the Canadian supply.

Consumption of Railway Sleepers.—The Belgian *Bulletin du Musée Commercial* gives the following information respecting the number of sleepers used on various railways. In France alone the six larger railway companies require a daily supply of more than 10,000 sleepers, making an annual consumption of over 3,650,000. As a tree of ordinary dimensions can not furnish much more than ten logs, it follows that more than a thousand fine trees are cut down every day solely for the purpose of supplying the necessary sleepers for the French railways. In the United States the amount required is still greater. Over 15 million sleepers are annually used in this country, thus necessitating the annual destruction of 80,000 hectares, or 197,600 acres of forests. The *Bulletin du Musée Commercial* estimates at more than 40 millions, the number of logs required for the railways of the world, and is of opinion that this estimate is rather below than above the mark.

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All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

JUVENILE LECTURES.

Professor ARMSTRONG, F.R.S., gave the first of his Juvenile Lectures on Wednesday, the 2nd inst., the subject being "How Chemists Work — an example to Boys and Girls."

The lecturer began by defining a chemist as one whose special province it was to find out what things were made of, and he considered that the chemist offered a special example to boys and girls, because they ought not to take things for granted, but to ask questions and investigate in the same way as the chemist did. The work of the old chemists was of a different character. They commenced by discovering new substances. Thus they found that iron pyrites, when exposed to the air and moisture, produced a new substance which, from its colour and glassy appearance, was called green vitriol. The green vitriol, when heated, produced a liquid which they called oil of vitriol, a highly corrosive fluid, as was shown by the experiment of pouring some upon a small quantity of syrup, when a large mass of spongy charcoal was produced. By pouring the oil of vitriol upon salt, they produced a fresh liquid, which, from its origin, they called spirit of salt. By heating saltpetre in it they produced a liquid which, from its power of dissolving silver and other metals, they named *aqua fortis*. When they tried the effect of *aqua fortis* upon gold, they found that it would not dissolve it, nor would the spirit of salt; but the two mixed together did dissolve it, and from this fact the mixture of the two liquids was called *aqua regia*.

It was not until chemists began to use the balance that their science got any further than the discovery of new substances, and the investigation of their properties. Lavoisier, the great chemist of the end of the last century, was the first to use the balance in this way. As an example of the use of the balance, Professor Armstrong, with his two little sons acting as his assistants, showed how the specific gravity of materials was obtained; that is to say. their weight as compared with an equal bulk of water. As an example, he showed how his two little boys had proved that flint, pebbles, and sand had all the same density. From this fact his audience could see that the work was by no means difficult, or beyond the powers of boys and girls. As another example, he showed how the balance could prove that iron, rusting in the air, became heavier, and therefore took up something from the air, the exact amount which was taken from the air being shown by conducting the experiment inside a bottle, the mouth of which was under water, so that the place of whatever was removed from the air was taken by water entering the bottle, the amount of the water thus entering showing the amount which had been taken out of the air.

He further showed that by burning phosphorus in a closed flask, and afterwards admitting water to supply the place of the air consumed, similar information could be gained, and information not only about the materials treated but about the constitution of the air itself.

Dr. Armstrong will deliver the second lecture of the Course on Wednesday next, the 9th inst., at 7 p.m.

LIST OF MEMBERS.

The new edition of the List of Members of the Society is now ready, and can be obtained by members on application to the Secretary.

COVERS FOR JOURNAL.

For the convenience of members wishing to bind their volumes of the *Journal*, cloth covers will be supplied post free for 1s. 6d. each, on application to the Secretary.

CANTOR LECTURES.

LIGHT AND COLOUR.

By Captain W. De W. Abney, C.B., F.R.S.

Lecture II.—Delivered December 3, 1888.

In the last lecture I finished the matching of the colour of pigments with parts of the spectrum, and to-night I will endeavour to show you that colourless bodies can be made coloured, under certain conditions, although the light that falls upon them is colourless. I told you last time that the waves of red light are such that if you put 38,000 end to end they make up an inch. If in the sea we have two sets of waves, one set of which is exactly half a wave behind the other, then the crest of the one wave will exactly fill the trough of the other, and instead of motion we shall have rest. Suppose I have a colourless body, whose thickness is comparable with a wave of red light, and that a wave of red light when reflected from the back surface is half a wave length behind that reflected from the front surface, we get darkness instead of light. The easiest way to obtain a colourless body answering to the above conditions is to use a soap film stretched across a vertical aperture. Its thickness is found to be comparable with a wave of light, and as it gradually thins by gravity, some part of the film becomes of the thickness that the reflection from the back surface is half a wave length behind that reflected from the front surface, the red is annihilated at such place. There will be another thickness of film in which the green light would be similarly absent, and yet another in which the blue is absent, and so on. The light reflected from the first locality would be the components of white less the red, in the second the same less the green, and in the third the same less the blue.

I can show you the kind of colour that is seen by the suppression of one small part of the spectrum, by using our patch-forming apparatus and passing a thin rod along the spectrum, which cuts out the part required. It will be seen that the patch is no longer white, but coloured. These colours, remember, are not simple colours, but white light, with some colour abstracted.

Putting a soap film on a ring in the beam of the electric light, at an angle of about 45° with it, the light is reflected on the screen, and a lens in the beam forms an image of the ring. At first the film appears white, but after a short interval of time coloured bars appear horizontally across it. Putting a piece of red glass in front of the beam, we have a succession of red and black bars, the red glass cutting off all the remaining colours. A piece of green glass placed in the beam shows green bars, and so on.

The bars are brighter at the bottom of the image, which is in reality the top of the film, for the reason that the film is of a thickness of $1\frac{1}{2}$, $2\frac{1}{2}$, $3\frac{1}{2}$, $4\frac{1}{2}$, $5\frac{1}{2}$, &c., wave lengths of the different coloured lights as we go from the top to the bottom of it. The bars gradually widen out and become very far apart, until we see only 3. I now cause a gentle current of gas to play on the film, and the coloured glass being withdrawn, we get a magnificent series of colours whirling one around the other. Peacock green, golden yellow, azure blue, succeed one another, and give a most brilliant effect. All these colours are due to white light falling on a colourless body.

The next experiment is to throw a small image of the film upon the slit of the spectroscope. We see the spectrum traversed by black lines curving down from red to blue, and rapidly shifting in position. These lines show the colours which are absent in the horizontal bars of coloured light reflected from the film, a section of which passes through the slit.

In this case we have a demonstration that the colours reflected from the film are not produced by any conversion of white light into coloured light, but by the abstraction of certain colours from the components of white light.

In the opal we have an example of interference colours, caused by a thin layer of material of different thicknesses, which abstract a certain component of white light in exactly the same manner as does the soap film. When we have the light from the varying thicknesses close together, as we have in the reflected beam in the patch-forming apparatus, they have very much the same appearance as has the opal.

But one more example of interferences, which is very beautiful, as time will not allow me to go into the theory of the matter; suffice it to say that if parallel lines be ruled on a surface very close together, and the beam of light be thrown on them, the "interferences" are such that pure colours are produced, and we have a spectrum.

Next let me show you that the colour of transparent bodies is also due to the abstrac-

tion of colour or colours from the white light.

In a cell I have a liquid which appears green. A spectrum is formed on the screen and in front of the slit of the spectroscope the cell is placed. You will see that the blue and most of the red is cut off, and that we only have green and a small band in the red left of the spectrum. Recombining the remainder of the spectrum to form a patch as before, we have a square of green light, and side by side with it is the patch formed by the reflected beam, which is coloured by the light which has not passed through the prisms, but only through the cell and the collimator. They are both absolutely of the same hue, showing that the recombined spectrum gives the same colour as the light after passing through the cell. Repeat the same with a red liquid or a blue liquid, and we obtain the same results.

A paper is coloured with the green dye which I had in the cell, and I allow the patch of white light to play on it, and you see the light reflected from it is green. In the path of the *reflected* beam I place a cell containing the green liquid, and throw the patch on *white* paper. The two patches, viz., the white light on the green paper, and the green light on the white paper, are the same colour. The white light which penetrates colouring matter is the same in the two cases, though when on the paper itself it traverses the colouring matter twice. This leads to an important axiom, viz., that the effect is the same whether the colouring matter is in contact with the paper or at a distance from it, so long as the eye receives the light which has traversed such colouring matter. I shall immediately take advantage of this, for I wish to show you that the depth of colour depends on the thickness of colouring matter through which the light passes. Of a double wedge-shaped trough, half is filled with pure water, and the other half with coloured water. Different thicknesses of the blue colouring matter are passed in front of the slit, and as the thickness is increased so the spectrum gets fainter in the blue than in the red.

The patch of white light is next formed, and the wedge of coloured liquid is again passed across the slit, and you will see that the colour deepens as it passes through different thicknesses. As this is true when the colouring matter is in front of the light, so must it be true when the colouring matter is in contact with the papers.

There is another feature which I must not pass over, *i.e.*, what is known as fluorescence, and though it does not enter into the effect of pigments used in water colours, yet it has much to say to the coloured materials of every-day wear. One of the most beautiful examples of this fluorescence is fluorescene. In the beam of the electric light a jar of water is placed, and in it is dropped a concentrated solution of the fluorescene. We have a fine example of fluorescence; the fine threads of liquid as they stretch towards the bottom appear of a brilliant green. I take another jar and repeat the same with quinine sulphate, and we have a gorgeous blue.

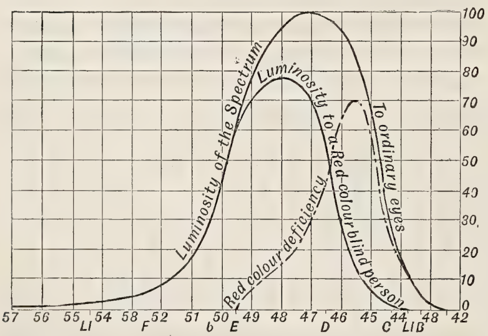
We will endeavour to trace this fluorescence to its source. I take a piece of card and brush it over with the solution of fluorescene, and place it in our colour patch; the different colours of the spectrum illuminate one after the other; we now can readily see the light which causes this fluorescence. It is in the green and the blue, but the light reflected from the fluorescene is of a totally different hue from the rest of the colour patch. So with the quinine. We see that when the colour patch is apparently dark, the paper covered with quinine shines out with peculiar lustre. The rays which excite fluorescence in this case are the invisible rays in the ultra violet. Common machine oil is fluorescent in the same part of the spectrum, but shines with a greenish light, and not blue.

We now come to the point when we must ascertain the second constant of colour, viz., its luminosity or brightness. Before showing how this is done for pigments, it will be necessary to show you how we can ascertain the luminosity of the spectrum itself. The luminosity of the spectrum varies greatly in different parts, the maximum luminosity in bright lights, such as the electric light, being in the yellow, and there is a degradation of brightness as we go towards each end of the spectrum. Now suppose we find that the reflected beam of white light, when the rotating sectors are as widely open as possible, is slightly brighter than a yellow patch formed from the yellow of the spectrum—it is manifest that other parts of the spectrum will be dimmer than that. If, now, in the reflected beam, I rotate the sectors at less than full aperture, less light will reach the screen, and it is evident that there are two parts of the spectrum, one on each side of the yellow, which will match the brightness of this degraded white.

In order to make this match, we place the

rod as before in front of the colour patch. One shadow is thrown on the white screen by the spectrum colour, and another shadow is thrown alongside it from the reflected beam. The white light and the coloured light, each light up one of the shadows. The slit in the card is moved across the spectrum till we find (say) that in the blue the blue illuminated shadow is too dark, and where the slit lets the green light through, the green illuminated shadow is too light. It is evident that at some intermediate place in the spectrum there the coloured shadow is neither too light nor too dark. This place in the spectrum is found by moving the slit rapidly, making the coloured shadow first too light and then too dark, diminishing the extent of the oscillations till equality of brightness is seen to the eye. The same procedure is carried on on the red side of the yellow. The angular aperture of the sectors is again altered, and a fresh determination made. Now the card in which the slit is cut carries a scale, and by means of a pointer the scale is read off, which tells us the exact part of the spectrum where the different equalities of brightness are established. We then use the apertures used as giving the relative luminosities of the different parts of the spectrum as measured, and make such a curve as we have below.

FIG. 1.

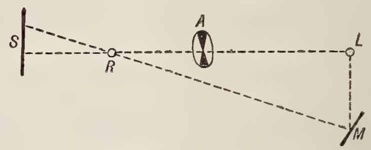


The method, then, of ascertaining the luminosity of a colour depends on the rapid oscillation of either the white or coloured shadow between "too light" and "too dark." This gives us a clue by which we can measure the luminosity of a coloured surface in a direct manner. The rotating sectors in Fig. 2 give us the means of doing this in an easy manner. Suppose the luminosity of a vermilion-coloured surface had to be compared with a white surface when both were illuminated, say, by gas light, the following procedure is adopted:—A square space of such a size is cut out of black paper so that its side is rather less than twice the breadth of the rod used to cast a shadow. One half of the aperture is

FIG. 2.

filled with a white surface, and the other half with the vermilion-coloured surface. The light, L, illuminates the whole of these, and the rod, R, placed in such a position that it casts a shadow on the white surface, the edge of the shadow being placed accurately at the junction of the vermilion and white surface. A flat silvered mirror, M, is placed at such a distance and at such an angle that the light it reflects casts a second shadow on the vermilion surface. Between R and L is placed the rotating sectors, A. The white strip is caused to be evidently too dark and then too light by altering the aperture of

FIG. 3.

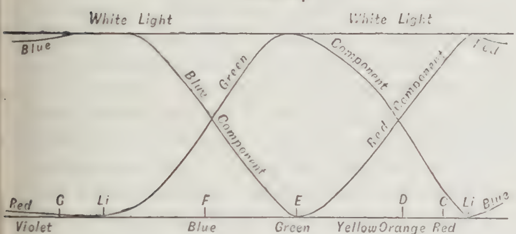


the sectors, and an oscillation of diminishing extent is rapidly made till the two shadows appeared equally luminous. A white screen is next substituted for the vermilion, and again a comparison made. The mean of the two sets of readings of angular apertures give the relative value of the two luminosities. It must be stated, however, that if the screen remained unshaded, as represented, the values would not be correct, since any diffused light which might be in the room would relatively illuminate the white surface more than the coloured one. To obviate this the receiving screen is placed in a box, in the front of which a narrow aperture is cut just wide enough to allow the two beams to

reach the screen. An aperture is also cut at the front angle of the box through which the observer can see the screen. When this apparatus is adopted, its efficiency is seen from the fact that when the apertures of the rotating sectors are closed the shadow on the white surface appeared quite black, which it would not have done had there been diffused light in any quantity present within the box. The box, it may be stated, is blackened inside, and is used in a darkened chamber. The mirror arrangement is useful, as any variation in the direct light also shows itself in the reflected light. Instead of gas light, reflected skylight, the electric light, or sun light can be employed by very obvious artifices, in some cases a gas light taking the place of the reflected beam.

It will be in your recollection that I said that the colour of an object depended on the eye of the observer. Vision, I have told you, depends on the fact that three colour sensations are necessary for the normal eye to see white light. There are in fact, as I have said, three sets of nerves, one responding to the blue, one to the green, and one to the red.

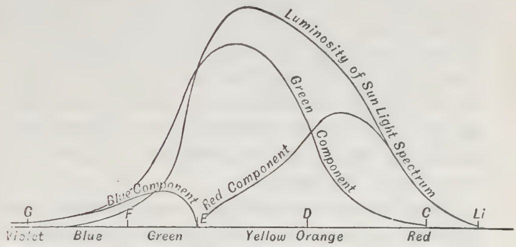
FIG. 4.



If one of these sensations be absent, then the eye does not see white light as we know it, but as—what would to us be—coloured light. The above diagram shows the three sensations as determined by Clerk Maxwell. The top line is supposed to be the spectrum as the eye sees it, all colours being of equal value. It will be noticed that at only three places in the spectrum is the colour pure, and all intermediate colours are made up by mixtures of two sensations, the height of the curves added together giving the height of the straight line parallel to the base of the curve.

Now, in order to test the eye for colour-blindness, it is only necessary to get a person so afflicted, to measure the luminosity of the spectrum. For evidently, if deficient (say) in red sensation, the spectrum would begin where the green colour sensation commences, and even then the luminosity would be much smaller, owing to the absence of such red sensation. Such a luminosity curve is seen in Fig. 5, and in the same figure is shown the

FIG. 5.



colour deficiency. It is comparatively easy to show the colour of the light which colour-blind people see. If a certain proportion of the light near the position which the blue lithium line occupies in spectrum be mixed with a certain proportion of the green light of the spectrum near E, and the two be combined in a patch, the colour of the patch will be that seen by a red colour-blind person. [This was shown on the screen, and the vermilion, emerald green, ultramarine and gamboge were placed in the mixed light, and the alteration in colour of the pigments noted.] In the same way the white light which, blue and green colour-blind see, can be shown.

In measuring the luminosity of the spectrum you cannot but have noticed that the shadow illuminated by the white light never appeared as white, but always coloured. Thus, when placed in juxtaposition with the yellow, the shadow illuminated by the white light appeared bluish; when with the green, reddish; and when with the blue, yellowish. The colour given to the shadows illuminated by the white light is merely the effect of contrast, and is due to error of judgment by the eye. The tendency of white in proximity to a colour is to make it to appear of the hue of the complementary colour, to which I shall draw attention in my next lecture.

Miscellaneous.

PROGRESS OF INDUSTRIAL EDUCATION IN EUROPE.

The following article is translated from M. Grosseteste's paper, read lately before the Industrial Society of Mulhouse :—

The Paris Exhibition of 1878, having shown to the industrial world the progress made on the Continent of Europe, also drew prominent attention to England, which, by the labours of various committees of inquiry as to her industrial progress, has served to prove that she has surpassed the expectations then held out. The following remarks are intended to present in a succinct form what has been the general British progress made, and the causes which have led to it.

The British textile industry, according to the reports of the Commissioners, cannot compete with Mulhouse for her rich impressions, nor with Roubaix for her all wool articles, especially in dyeing, as carried on at Bradford.

Verviers ships to Scotland yarns produced on English machines, Bale has its ribbons, Crefeld its velvets and silks, Chemnitz its mixed fabrics, the popularity and success of which indicate industrial transformations conducted with an energy rarely equalled in England. Great Britain, however, retains still its superiority in the construction of machines. On the other hand, its exports continue very large, and its textile products, soft woollen goods especially, improve daily, thanks to the art schools, which turn out native designers whose works have great success. It is the same with the good taste which characterises certain of her artistic products in porcelain, glass, and decorative objects; but still France and its emulators, Belgium and Italy, enjoy an incontestible superiority.

To judge of the progress made in half a century in Continental industry, it may be well to recall that only in 1825 were abolished the laws punishing the employment of English workmen abroad, and that about 1835 the prohibition to export spinning machines was removed. It became, therefore, necessary for the Continent to face a complete industrial organisation, unknown to those who had not access to English factories. Technical schools were at once established, and engineers were sent to England, to study the course of operations, and to establish, subsequently, industrial lectures. The greater part of these schools were founded, and are still supported by the Governments; they turn out, at present, a considerable number of qualified chemists and engineers, of whom a certain number find places in England.

These young men, in general, possess a thorough knowledge of the sciences which concern their special manufacture or industry, and all the scientific and industrial discoveries, which belong to them, are familiar.

The technical schools for those who would become directors or foremen are more recent on the Continent than the polytechnic schools. We may cite as types those of Wintherthur, Chemnitz, Komotau (Austria), and St. Etienne, the last named specially devoted to mining.

As for the schools of art founded in France under the First Empire, these vegetated only up to their re-organisation, which dates about twenty-five years back. Attempts have been made to establish preparatory schools for the technical ones; these exist in Prussia and Bavaria. In France, that of Rheims is the best. These send up their scholars to the technical schools, or launch them in trade or iudustry at once, if they possess a sufficient amount of theoretical and practical knowledge to be useful.

In France, in the schools of the type of Rheims, the education is gratuitous. It may be added that this custom is too recent to allow of their having yet furnished to industry any important contingent of foremen.

The weaving schools are attended by youths intended either for commerce or industry. They are much in favour, the best proof of which is the establishment of the splendid building at Crefeld, constructed conjointly by the State, the town, and business men. There are also evening classes on weaving for workmen, which are, however, not very well attended.

It may be remarked that notwithstanding the patronage and support of various industrial societies and chambers of commerce on the Continent, these different constituted bodies have but a limited sphere of action, which renders their organisation and results inferior to those of the Department of Science and Art in England, and the City of London Guild, supported by the Corporation. On the contrary, however, the English operative does not possess, as do a large proportion of foreign workmen, a knowledge of industrial drawing, acquired gratuitously by adults in France, Belgium, and Italy, or the elementary instruction which the workman possesses in Switzerland and Germany. In France, the municipalities of the large towns subsidise gratuitous courses of lectures in drawing, modelling, sculpture, and painting, which are eagerly attended, and create great emulation among the workmen. In Germany, Holland, and France, in districts where the population is scattered, and combination in manufactures is impossible, small industrial schools are established, where children are taught the principles of petty trades, such as carving in wood, inlaying, clock-making, &c.

England has establishments known as mechanics' institutes, which are being reorganised, and she possesses also art schools, founded by co-operative and industrial societies. It is much to be wished that these institutions should take a lesson from what is done abroad, without requiring from the young who are to become workmen or managers a merely theoretic instruction up to 22 or 23 years, as in the polytechnic schools, but to stop at 18 or 19, so that they may subsequently acquire practical knowledge in the workshop or factory.

There is, however, a broad difference between young men intended to become chiefs of important industrial establishments, and those who are to be merely managers or owners of smaller works.

The former, in universities or special schools, can easily obtain the amount of necessary knowledge,

while the latter are obliged in the interest of their future, to add the acquired practice of the workshop to their theoretical knowledge.

Certain schools, have, with this object, added machine-rooms and workshops to their locale of instruction, but the number of these is limited, and they have insufficient funds to remunerate professors.

There are at Manchester, Bradford, and Glasgow, secondary schools, where science and modern languages are taught; these schools are lost in the mass of educational establishments, and are usually not within the means of the artisan class. It is these last, who on leaving the preparatory schools, should be permitted to profit more readily by the classes at the Department of Science and Art, and the City Guilds.

There have recently been opened, in the north of England, weaving schools, and also, in Yorkshire, drawing classes. In fact, there do not exist, in England, institutions like those which the Continent possesses; but the City Guilds' Institute of the Corporation of London endeavours, by example and by money grants, to create in the manufacturing centres similar schools to the Continental polytechnics, and to render drawing obligatory in all the English schools.

In Russia, the technical school of Moscow is copied from the model of the Conservatoire of Arts and Manufactures of Paris, as far as the theoretical education is concerned; the practical instruction is more extended, so as to permit the students to carry out important works for the public—works executed partly by the students, and partly by foreign workmen. The number of young men who study there is not, however, very large. As for elementary technical schools, they scarcely exist there, and from the average instruction of the students who attend the classes, it is doubtful whether they will become first-class workmen, for the instruction they have received will not permit them to follow the more advanced classes of arts and manufactures.

AN ELECTRIC TRAVELLING CRANE.

The application of electricity to the working of cranes has been increasing of late. Perhaps the first practical use of this agent for lifting purposes was the electric hoist of Dr. J. Hopkinson, exhibited at the Paris Electrical Exhibition of 1881. Since then it has been applied to hotel lifts and cranes, but not to any great extent. Quite recently, however, an electric crane of great power was described by Mr. W. Anderson at the Bath meeting of the British Association (see *Journal*, vol. xxxvi, p. 1092); and another large travelling crane, worked entirely by the electric current, has been introduced into the well-known timber-yard of Mr. Herrmann, at Limehouse. This crane has been adopted to avoid the insurance rates required for steam cranes, which are obviously dangerous in a wood-yard. It has been designed by Messrs. R. E. Compton and Co., of Chelmsford, and is found to do its duty very satisfactorily. Hydraulic power might have been used for the crane, but there was already an electric plant for lighting purposes on the premises, and hence electricity was adopted. The new crane runs on a tramway along the roof of the timber warehouse, and is used to raise the incoming logs of timber from the canal. An electric motor is attached to the frame of the crane, and geared with friction gearing of the Raworth type to a central shaft, which, by means of three levers and a foot-brake, performs the three operations of hoisting, slewing, and propelling the crane. The current is conveyed to the electric motor by two copper tubes, laid along the tramway, and taken off suitable contacts. In other respects the crane is of the ordinary build. The power is derived from an 18-unit Compton dynamo, which also supplies 300 incandescent lamps employed for lighting one of the factories. It gives a current having an electromotive force of 110 volts; and some 30 ampères are used to work the crane. It was specified that the crane should lift 15 cwt. as a *maximum* load, raise 10 cwt. at a speed of 80 ft. per second, and slew at the same speed; but as a matter of fact it can lift 18 cwt, and in other respects the specification values have been improved upon.—*The Times*.

EAST AFRICAN ECONOMIC NATURAL HISTORY.

Some East African tribes are great consumers of fish, others of the flesh of land animals. The inhabitants of the region south of Zanzibar are hard-working fishermen and cattle raisers. Among the Rufigi tribes, broad-tailed, dew-lapped sheep attain large size, poultry is abundant, and fish are plentiful, heavy ones being speared from the sand islands in the river. The Mawanda live on fish and tubers, and spear hippopotami for the sake of the flesh. The Wagangi, who live on a small island below the Shughuli Falls, seem to get their living principally by waiting for the fish which are carried down the falls and thrown up into the potholes in the rocks, some being three feet long. The Makonde eat a very elegant green serpent common in their country; The Matambwe, a people fast becoming extinct, live for the most part on fish, cultivating no cereal, but sometimes buying grain with the salt which they prepare.

The Kingani river abounds with fish of many descriptions, some being quite equal in flavour to the average sea fish of the Zanzibar coast; one, the *mzozo*, possesses a firmness and flavour not surpassed by any fish found in the tropics. In general appearance it exactly resembles a river carp, but it is furnished with a single row of very fine, sharp teeth, and has a roughness of the skin below the gills not

met with in vegetable-feeding fish. The men of this district are very clever at making fish-traps of various descriptions, covering the adjacent low country with weirs, stake-traps, and long lanes of reed fences leading up to them. After each rise and inundation large quantities of fish are taken in this way.

Peoples dwelling on Lake Nyassa mostly engage in the capture of the finny tribes inhabiting the lake and the rivers which feed it. For example, in the Lintippe, weirs are thrown across the most available places in the stream, and in these fish-baskets are set. Canoes ascend the Lueia as far as its cataracts, with men who fish at the falls for the *sanjika* as they go up to spawn. The fishermen use a small net on the fork of a long branch, and this they place in quiet crevices of the rocks, where the fish go to rest for a little in their struggle up stream. In some villages, hundreds of yards of excellent fishing nets may be seen drying on stakes on the beach.

The Mandandas, in Southern Mozambique, are dog eaters, and keep their dogs fat and in good condition for roasting. They also eat rats and are well supplied with them. Fear of their Zulu neighbours has had much to do in creating these tastes, as goats and fowls would soon be stolen.

The Waguba are very fond of meat, and will eat the flesh of almost any animal, monkeys being looked upon as a delicacy.

The dairy farms of Uhha produce packages of butter, and the poorer districts of Lake Tanganyika put up parcels of dried fish, which are sent far and wide throughout the country. This fishing industry is a very extensive one. The Warundi have small catamarans, made of four or five trunks of the pith tree strung together, from which they angle for medium-sized fish. But the more important work goes on at night, in little hollowed-out log canoes, upwards of 200 of which may be counted at one time. Each canoe has a fire to attract the fish, which are caught in large hand-nets. A seine-net is also used in some parts of the lake, and for the larger fish immense wicker traps are sunk to the bottom. Fish traps are anchored off the shore to entice the large and oily *senga*. Bees are domesticated.

Near Maliwandu's, in the neighbourhood of Lake Tanganyika, at the end of November, the trees are thickly covered with large caterpillars, three or four inches long, and as thick as the forefinger. The natives collect them in great numbers, disembowel and roast them, and preserve them for food. One kind is of a light pea-green colour; another is dark, with white spots and sharp spines on the back.

In the Mangballe country, during the ant season, immense quantities of that insect are consumed. Ant paste, eaten with maize bread, reminds one of the flavour of liver sausage. Fowls cooked in ant oil taste as if they had been done in butter. The ant alluded to is the gravid female termite.

The natives of Mashuna Land covet meat in any shape, fat or lean, fresh or putrid, but have no domestic animals. Hippopotamus flesh is largely consumed.

The Masai keep many cattle, which they milk and eat the flesh of. Cows are killed by inserting a long, sharp, narrow knife into the back of the neck, about halfway between the head and shoulders. The animal drops at once. The skin encircling the wound is then raised, so as to form a bag, in which the blood collects; while yet warm the men drink it, one taking his fill at a time. At the best of times the cows give little more than half the milk afforded by English breeds. The article of diet which the Masai prefer to all others is curdled milk; when they can get plenty of this they will not touch any other. They are most careful to keep their milk calabashes clean by scouring them with live charcoal. They only eat meat when they cannot get enough milk, which is the case in the dry season. They cultivate no ground and eat no fruit.

The diet of the people of Uganda consists of milk and bananas.

In the Remimba river, Cazembe's country, appears a fish called *pendes*, small but savoury; they are equally good and larger at Tete. This fish has been compared by travellers with the *dourada* of Portugal. Among the dried fish brought by the Kaffirs for sale appear *garopas*, *bagre*, and "rock fish," all peculiar to salt water. The *garopa* of Madeira is a small fish much prized.

The *bagre* and "rock-fish" are unknown to science. The Muiza tribe in this country lance hippopotami in the rivers, all Kaffirs apparently prizing its flesh, and the more tainted it is the better they like it.

The Wahehe depend mainly on their cattle, and eat their meat nearly raw.

The Kaffir ways of killing elephants are as follow:—The sportsman, armed with a spear weighing about 8 lb., climbs a tree overhanging the animal's usual path, and thrusts the weapon into its neck as it passes; or on sighting a herd, they separate some of the animals by whooping, and then slip at them trained dogs, that engage their attention by barking from some distance; meanwhile the hunters, watching their opportunity, hamstring the elephants and despatch them with spears.

A beetle, called *kungjungjudu*, which does much damage to the crops, is eaten by the natives of the Baghermi country, south of Lake Chad.

THE WORLD'S COTTON CONSUMPTION.

The greater part of the cotton produced in the world is consumed in the United Kingdom, where the consumption has increased from 1,014,000 bales of 400 lbs. each in the period 1836-1840, to an average of 3,117,000 bales for the period 1876-1880, and to 3,700,000 bales during the last four years. After the United Kingdom, says the *Bulletin du Musée Commercial*, comes the European Continent, taken as a whole the consumption of which has

increased during the same period from 521,000 to 3,400,000 bales. The third place is held by the United States, which surpasses all other countries in the rate of increase, as the consumption in this country rose from 242,000 bales in 1840 to 2,137,000 bales in 1884-1885. In a work lately published in Stuttgart, by Dr. F. X. Von Neumann Spallart, entitled *Uebersichten der Weltwirthschaft*, the total number of spindles has been as follows during each of the five years ended 1886:—

——	1882.	1883.	1884.	1885.	1886.
	Number.	Number.	Number.	Number.	Number.
United Kingdom	41,000,000	42,000,000	43,000,000	43,000,000	42,700,000
European Continent	24,855,090	22,500,000	22,650,000	22,750,000	22,900,000
United States	12,000,000	12,600,000	13,200,000	13,250,000	13,350,000
British India	1,620,000	1,700,000	1,950,000	2,000,000	2,100,000
Total	79,175,000	78,800,000	80,800,000	81,000,000	81,050,000

As regards each of the principal cotton consuming countries, the following estimate has been formed of the number of spindles in each, based upon returns published in the respective countries:—

Country.	Year.	Number of Spindles.
United Kingdom	1885	43,349,000
United States	1885	13,250,000
France	1882	3,927,000
Germany	1883	4,900,000
Russia	1883	4,000,000
Austria-Hungary	1885	2,077,000
British India	1885	3,048,000
Switzerland	1884	1,880,000
Spain	1883	1,855,000
Italy	1883	1,200,000
Belgium	1883	650,000
Sweden and Norway	1883	310,000
Holland	1883	250,000

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings at Eight o'clock:—

JANUARY 16.—"The Channel Tunnel." By COLONEL HOZIER. SIR FREDERICK BRAMWELL, Bart., D.C.L., F.R.S., will preside.

JANUARY 23.—"Electric Meters for Central Stations." By PROF. GEORGE FORBES. W. H. PREECE, F.R.S., will preside.

JANUARY 30.—"The Construction of Photographic Lenses." By CONRAD BECK.

Papers for which no dates have as yet been fixed:—

"The Status of the County Council." By G. L. GOMME.

"The Forth Bridge." By BENJAMIN BAKER, M.Inst.C.E.

"Salt." By PETER LUND SIMMONDS.

"The Manufacture of Aluminium." By WILLIAM ANDERSON, M.Inst.C.E.

"Automatic Selling Machines." By J. G. LORRAIN.

"Secondary Batteries." By W. H. PREECE, F.R.S.

"Arc Lamps and their Mechanism." By Prof. SILVANUS P. THOMPSON.

"The Irish Lace Industry." By ALAN S. COLE.

"The Use of Spirit as an Agent in Prime Movers." By A. F. YARROW.

FOREIGN AND COLONIAL SECTION.

Tuesday evenings, at Eight o'clock:—

JANUARY 29.—"Gold Mining in Colorado." By THOMAS W. GOAD.

FEBRUARY 19.—"Slavery in its relation to Trade in Tropical Africa." By Commander V. LOVETT CAMERON, C.B., R.N.

MARCH 12.—"Borneo." By ROBERT PRITCHETT.

APPLIED ART SECTION.

Tuesday evenings, at Eight o'clock:—

JANUARY 22.—"Some Recent Movements in Relation to the Applied Arts." By SIR JAMES D. LINTON.

FEBRUARY 5.—"Manufacture of Sèvres Porcelain." By EDOUARD GARNIER.

FEBRUARY 26.—"English Bookbinding in the Reign of Henry VIII." By W. H. J. WEALE.

MARCH 19.—"The Art of the Jeweller." By CARLO GIULIANO.

APRIL 9.—

MAY 14.—"Venetian Glass." By DR. SALVIATI

INDIAN SECTION.

Friday evenings, at Eight o'clock:—

JANUARY 25.—"The Trade of India and Persia with East Africa, past and present." By H. H. JOHNSTON. MAJOR-GENERAL SIR FREDERICK J. GOLDSMID, K.C.S.I., C.B., will preside.

FEBRUARY 15.—"The Progress of the Railways and Trade of India." By SIR JULAND DANVERS, K.C.S.I.

MARCH 8.—"The Present Condition and the Prospects of Indian Agriculture." By PROF. ROBERT WALLACE.

MARCH 29.—

MAY 3.—"The Karun as a Trade Route." By MAJOR-GENERAL SIR R. MURDOCH SMITH, K.C.M.G.

MAY 24.—"Indian Wheats." By JOHN McDOUGALL.

CANTOR LECTURES.

The following courses of Cantor Lectures will be delivered on Monday evenings at Eight o'clock:—

ALAN S. COLE, "Egyptian Tapestry." Two Lectures.
January 21, 28.

W. J. LINTON, "Wood Engraving." Two Lectures.
February 11, 18.

WALTER CRANE, "The Decoration and Illustration of Books." Three Lectures.
March 4, 11, 18.

C. V. BOYS, F.R.S., "Instruments for the Measurement of Radiant Heat." Four Lectures.
March 25; April 1, 8, 15.

H. GRAHAM HARRIS, M.Inst.C.E., "Heat Engines other than Steam." Four Lectures.
May 6, 13, 20, 27.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, JAN. 7...Geographical, University of London, Burlington-gardens, W., 8½ p.m. Mr. F. S. Arnot, "Journey over the Central Plateau of Africa, from Natal to Benguella, and past the Sources of the Zambesi to the Sources of the Congo."

Medical, 11, Chandos-street, W., 8½ p.m.

Victoria Institute, 7, Adelphi-terrace, W.C., 8 p.m. The Rev. F. A. Walker, "Colours in Nature."

London Institution, Finsbury-circus, E.C., 5 p.m. Mr. Harry Furniss, "Art and Artists." (With Illustrations.)

TUESDAY, JAN. 8...Royal Institution, Albemarle-street, W., 3 p.m. (Juvenile Lectures.) Professor Dewar, "Clouds and Cloudland." (Lecture VI.)

Medical and Chirurgical, 53, Berners-street, Oxford-street, W., 8½ p.m.

Civil Engineers, 25, Great George-street, S.W., 8 p.m. Mr. Edgar Worthington, "The Compound Principle applied to Locomotives."

Anthropological, 3, Hanover-square, W., 8½ p.m. 1. Mr. T. W. Shore, "The Distribution and Density of the old British population of Hampshire." 2. Miss A. W. Buckland, "The monument known as 'King Orry's Grave,' compared with tumuli in Gloucestershire."

Biblical Archæology, 9, Conduit-street, W., 8 p.m. Annual Meeting.

WEDNESDAY, JAN. 9...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Juvenile Lecture.) Dr. Armstrong, "How Chemists Work." (Lecture II.)

Geological, Burlington-house, W., 8 p.m. 1. Prof. J. W. Judd, "The Growth of Crystals in Igneous Rocks after their Consolidation." 2. Prof. J. W. Judd, "The Tertiary Volcanoes of the Western Isles of Scotland."

Graphic, University College, W.C., 8 p.m.

Microscopical, King's College, W.C., 8 p.m. 1. Mr. A. D. Michael, "Some Observations on the Special Internal Anatomy of *Uropoda Krameri*." 2. Abbé Count F. Castracane, "Reproduction and Multiplication of Diatoms."

Pharmaceutical, 17, Bloomsbury-square, W.C., 8 p.m.

Royal Literary Fund, 10, John-street, Adelphi, W.C., 3 p.m.

Entomological, 11, Chandos-street, W., 7 p.m. Annual Meeting. Election of Officers and Council for 1889, and the President's Address.

Civil and Mechanical Engineers, Westminster Palace Hotel, S.W., 7 p.m. Mr. A. F. Bruce, "The Cost of Executing some classes of Engineering Work."

THURSDAY, JAN. 10....Royal, Burlington-house, W., 4½ p.m.
Antiquaries, Burlington-house, W., 8½ p.m.

London Institution, Finsbury-circus, E.C., 6 p.m. Prof. Flower, "Pygmies."

Electrical Engineers, 25, Great George-street, S.W., 8 p.m. Sir William Thomson, President, Address.

Mathematical, 22, Albemarle-street, W., 8 p.m.

FRIDAY, JAN. 11...Civil Engineers, 25, Great George-street, S.W., 7½ p.m. (Students' Meeting.) Mr. Geo. A. Beck, "Refrigeration, and the Artificial Production of Cold."

Astronomical, Burlington-house, W., 8 p.m.

Clinical, 53, Berners-street, W., 8½ p.m.

Quekett Microscopical Club, University College, W.C., 8 p.m.

New Shakspere, University College, W.C., 8 p.m. Mr. R. G. Moulton, "The distinction between Classical and Shaksperian Plot, illustrated by recasting the plot of Macbeth in Classic form."

SATURDAY, JAN. 12 ... Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m.

Journal of the Society of Arts.

No. 1,886. Vol. XXXVII.

FRIDAY, JANUARY 11, 1889.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

SWINEY PRIZE.

The adjudicators under the will of the late Dr. Swiney are summoned to meet on Monday, the 21st January, 1889, to make the award in conformity with the terms of the bequest contained in the will of the testator.

By order,

H. Trueman Wood,
Secretary.

JUVENILE LECTURES.

On Wednesday evening, the 9th inst., Professor Armstrong, F.R.S., delivered the second and concluding lecture of his course of Juvenile Lectures on "How Chemists Work—an example to Boys and Girls."

The lecturer, after recapitulating those points in the last lecture relating to the rust of iron and the burning of phosphorus in a closed flask, showed how the chemist picked up the clues which he obtained by experiment in the same way as a detective set about finding a criminal. He then burnt some phosphorus in a plate, and showed that the white snow-like substance which was thrown down made a hissing sound when placed in water, while the unburnt phosphorus was unaltered by immersion in water, which proved that the phosphorus was changed by addition from the air. He also showed that when phosphorus was burnt in a closed flask, although heat was thrown off, no loss of weight was sustained; from this use of the balance we learnt that heat was not, as was formerly believed, a material substance.

Dr. Armstrong showed by heating red lead in a closed tube that gas was driven off, which proved, on testing, to be of the same nature as that absorbed by the iron filings as shown in the previous lecture.

In conclusion, the composition of chalk and of water were explained. When water was poured upon chalk and lime the chalk was left merely wet, while the lime was slaked. It was seen that by heating chalk to a red heat lime was obtained, owing to the passing off of a gas, by which action weight was lost. The complement of this experiment was then shown by the building up of chalk again by the mixture with lime water of the gas which had been thrown off. Chemists were long baffled by the difficulties attendant on the breaking up of water into its elements, but by following out the clues which had previously been obtained, it became possible to discover the composition of water. Dr. Armstrong exhibited the process to the audience, and urged all the boys and girls present to ask intelligent questions, and not to be satisfied until they obtained satisfactory answers. He said it was not what we were told but what we learnt for ourselves that was true knowledge.

The Chairman (Lord Sudeley) proposed a hearty vote of thanks to Dr. Armstrong for his interesting course of lectures, which was carried unanimously.

CANTOR LECTURES.

LIGHT AND COLOUR.

By Captain W. De W. Abney, C.B., F.R.S.

Lecture III.—Delivered Dec. 10, 1888.

My first business to-night is to show you the third constant of colour. You will recollect I told you that the hue is one constant. the luminosity of colour the second, and that the third is the purity of colour. The purity of colour is that which is perhaps the most difficult to measure, but not so difficult to describe. No colour is pure unless it is unmixed with white light. I propose to show you how you can get colour so impure that eventually the colour will entirely disappear, and will leave to your eyes only the impression of white. I think my first experiment will very likely demonstate this.

The apparatus is exactly that which you saw before, viz., the colour-patch apparatus. I am only allowing a small beam of light to come through the prisms, to get a small round

patch on the screen, instead of the big white patch square to which you are accustomed. Now, supposing I pass the slit in the card through the spectrum, that patch becomes coloured with any of the colours with which I wish to experiment. The reflected beam gives us a large square of white light, which I superpose over the small coloured patch. Let us see whether we can extinguish that coloured light or not. I may take red, green, or blue, and then if I place the rotating sectors in front of the coloured beam you will see that by making the coloured patch fainter it will entirely disappear. This is the case whether we have a blue, red, or a green patch. That the colour is still present I can demonstrate by cutting off the white light, when you see the colour on the screen.

The lesson I wish to inculcate is this—that the blue, green, and red which you saw disappear, and which were mixed with more and more white light, are essentially impure colours, and most impure where the white light is strongest. It was by this method that originally the luminosity of the spectrum was measured. It was seen how much white light it took to extinguish a colour on a screen, and according to the white light it took, so the luminosity was supposed to be proportional to it. To my mind it is not a very satisfactory way of testing luminosity, and I think the way I showed you in the last lecture is far preferable.

There is another deduction I want to point out with reference to this, which is of importance to artists. In water-colour painting it is well known that in order to get what artists call a certain amount of warmth in the picture, a wash of yellow ochre is very often given to the white paper before it is worked upon. Those of you who are water-colour painters know very well that, although you may appear to have a wash of water colour on the paper when it is moist, yet when it is very dry apparently there is nothing but white left behind. The colour is so diluted with white that it does not appear to the eye, but the colour is there all the same, and if you increase but slightly the amount of pigment the colour will be visible. All the colours you place on that apparently white paper mix with the yellow ochre. Remember, then, that if you have a wash of water-colour on a sheet of white paper, and it does not appear to the eye, yet subsequent washes of any colour will bring out that colour, and in the case of yellow ochre will give that warmth which artists so often desire to have upon their sketches.

Now, then, as to the question of diluting one colour with another. We have, so far, only diluted a pure colour with white light; but in diluting one colour with another we enter into a region which has been traversed by a great many experimenters, amongst others by Clerk Maxwell and Lord Rayleigh, and there is an immense amount of interest in the results which have been obtained. Some of them I hope to show you in as simple a manner as I possibly can. But I want you to recollect that one can only touch on the fringe of the subject, as it were, in an hour's lecture.

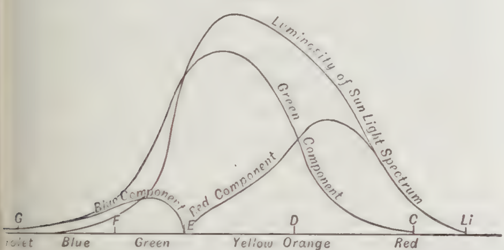
Let me pass some slits through the spectrum of this patch-forming apparatus. First we have a patch of white light, and by a simple means I propose to show you what colours come through the slits placed in the spectrum. If I put another lens in front of the big lens, which condenses the spectrum to form the white patch, you will find I can get the spectrum itself fairly defined upon the same screen as that on which the patch is formed. The second lens in reality produces an image of the first spectrum which was formed on the focussing screen. Now suppose I pass a series of slits through this you will see the kind of light I am going to use. I have here two colours, and I will show you what is the effect of blending those two—blue and red—together; I have only to remove this lens, and we see an orange patch, I will allow another colour to come through a third slit (the card has several), and replacing the small lens we see the three colours. If I blend those three I get a green, and so I may go on blending the colours by passing more slits through the spectrum. Here I have four, and I dare-say we shall get a different result again—still it is a green. Perhaps one of the most interesting ways of showing colour mixtures is to take away both lenses, and let different parts of the spectrum pass through the slits, and paint itself upon the screen. We begin with the red, and here we have a red patch. Then I add yellow which forms orange, and then I shall add a third patch, and pink is formed, then green and blue by adding others until we get nearly a white light in the centre; so I can keep passing these slits through the spectrum, and get many varieties of colour.

Thus we see it is not necessary to have the whole spectrum in order to get certain coloured lights. All we have to do is to take certain portions of the spectrum, and if properly

chosen their combination gives us what we call a white light. For example, I wish to show a crucial experiment. I believe every artist will tell you that the combination of blue and yellow gives a green. Now I want to demonstrate that blue and yellow do not give you a green in accordance with the artist's notion, but something totally different. I form my white patch on the screen, as before, and by means of the small lens set a spectrum on the screen, passing through the spectrum two slits, cutting off in the one case all the spectrum except the yellow, and in the other all except the blue, which you see on the screen, and then removing the small lens, instead of getting green we get white. You have seen two parts of the spectrum which must be combined in order to give white. In other words, blue and yellow give white, not green. This is a crucial experiment, because on this is based a great deal of the theory of colour mixtures, and I want you to bear that in mind.

I would once more ask you to remember that the eye only sees three colours really, viz., red, green, blue, and that all the other colours which are seen by the eye are composed of two or more of these three colours. There is a very little blue in the extreme red end of the spectrum, and a very little red in the extreme violet. This is according to Clerk Maxwell.

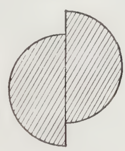
FIG. 1.



I told you the luminosity of the spectrum was greatest in the green. In the diagram (Fig. 1) we have the luminosity curve on a normal or wave length scale; the maximum luminosity is therefore a little bit more towards the violet end of the spectrum than in the prismatic spectrum; the red component, the green component, and the blue component of the luminosity of white light, are shown in the diagram. These three luminosities together make up the luminosity of the spectrum of white light. The blue, you will notice, has but little luminosity compared with the green and the red. The luminosity in the green is far greater than any of the other two sensations. This I wish to get firmly impressed in your minds, noting that the blue is a much less important colour than green or red; in other words, it is far preferable to be colour-blind to blue light than to green or to red light. This, of course, is founded on Clerk Maxwell's theory, and is derived from my own measurements. I think the researches which General Festing and I have made bear out in a very great measure, although they differ in some respects in detail, the results which Clerk Maxwell himself got. It may be said that we have been dealing with spectrum colours, and not the colours of every-day life. Is it possible that if you are not dealing with pure colours that yet you get the same result? The answer to this question I will give by experiment in a very simple manner, and we shall see that we do get the same result whether we are using the colours of pigments or the simple colours of the spectrum. Recollect there were only two rays combined to form white in the experiment I showed, whereas in the colour of a pigment you may have a great many colours combined, although they give the sensation of one colour to the eye.

The electric light illuminates a circular aperture, behind which is ground glass, and by a lens I can throw an image of this aperture upon the screen. Instead of a simple lens I have here a lens which is divided into two halves. The centre of one half lens is raised slightly above the other. Now every portion

FIG. 2.



of the lens will give an image by itself, and therefore each half of the lens will give a separate image, one overlapping the other. Thus on the screen we now have two images of the aperture which is in front of the lantern. If I put a piece of yellow glass in front of one half of this lens, I form a yellow disc, and if I put a piece of blue glass in front of the other I form a blue disc, and where the two overlap you have the real colour which a mixture of the blue and yellow lights will give. You can see that yellow and blue do not make green, but white.

But the artist, after all said and done, is not wrong in one way, because he often mixes

his pigments together and not the colours of of them. Supposing I put the yellow glass in front of the aperture, I then get two yellow discs; if the blue glass be placed in front of the yellow glass, however, I get two green discs. The artist, after all, when he mixes his pigments in that way, is not wrong. In other words, he does get green when he mixes blue and yellow together, but he is wrong when he mixes the light coming from each separately.

Now let us see why this is the case. I must come back to my spectrum, to which we have always to refer when we are dealing with colour. I will put the two pieces of glass successively in front of the light passing into the slit, and ask you to notice what happens. With the blue glass a great deal of red is cut off, and a good deal of yellow; the blue is nearly as bright as it was before. If I substitute a piece of yellow glass for the blue, the blue is cut off, and the green left almost as bright as it was before, and the yellow and red are also left. In the one case, recollect, we had the blue and the green left, and the red cut off. In the other case we had the blue cut off, and the green and the red left. If we take one from the other we get the green left, so that if I put these two glasses together in front we ought to get the green left, which is the case. Now if I take away the small lens from the front of the big lens, and form a patch, we have that patch of the same green which you saw in our previous experiment. Here, then, we have the combination of blue and yellow making up the green. Now for one more experiment in relation to this. If a blue disc and a yellow disc be rotated together, and, if what I have said be true, instead of forming green they ought to form grey, *i.e.*, degraded white. Let us see whether it does so. The two discs are now rotating, and we get what is not, at all events, far from grey. Thus, in every case we get a blue or a yellow forming a grey or white under certain conditions, that is to say, when the blue and the yellow are each presented to the eye separately.

Now, I shall have to show you why it is that when they are not presented to the eye separately they form the green. This is a yellow chromate solution in a cell. I place the chromate solution in front of the lantern; the yellow light falls on the blue sector, which is now at rest, and we have a green. The yellow is almost unaffected, but there is no doubt about the blue becoming green. Prussian blue used in a similar manner leaves the blue sector nearly unaltered, but the yellow has now become green. If I take a still darker blue, the green becomes more pronounced than it was before. You recollect I proved to you, or tried to do so, that it did not matter whether a pigment was next to the paper, or away from the paper, so long as it was in front of the source of light. Now in the case before you, when you mix yellow and blue together, as an artist mixes pigments, you have one particle of yellow, say, in front of a particle of blue, and, therefore, the light which passes through the yellow is that which reaches the blue particle, and that they both absorbed I showed you in the spectrum. The yellow absorbed in the blue alone, and the blue absorbed in the yellow and red, green rays would, therefore, only come through the two.

For the same reason, when I held the yellow glass in front of the beam of light, the blue became green, simply because the yellow glass blocked out the blue, and the blue particles on the paper only allowed the green to pass through. This exemplifies again what I told you, that it does not matter where you have your colouring matter, whether it is miles away from the paper or absolutely in contact with it, so long as it is between the source of light and the paper itself. But artists, whether they do so knowingly or not, employ both methods of mixture of colour. We know perfectly well that gamboge and indigo are a very favourite mixture for greens; but, on the other hand, you will find that in some of the most beautiful works of art broad washes, to obtain light and shadow, are not adhered to, but, as in the execution of portraits, stippling is resorted to. Now stippling means that different colours in fine dots are placed close to one another, so close that the eye cannot separate them, and the colours blend one into the other. Thus, if you have, for instance, a great many yellow dots distributed amongst a great many blue dots, the result is exactly the same as you saw on the screen, viz., instead of getting a green the general effect is a grey. This is the whole principle on which stippling depends, viz., the juxtaposition of very different colours to give an effect which otherwise cannot be obtained. Now, the explanation may be new or it may be old, but from having examined a large number of stippled water-colour drawings, one can only come to the conclusion that where many of the tender greys which are often seen are simply due to the fact that you have two or more colours in dots and fine lines in juxtaposition one to

another, which colours, when combined in a rotating apparatus such as you have seen, give the effect of grey to the eye.

I must now repeat the experiment with which I began my series of lectures, viz., that three colours will give you white; and I think that this will be a proof—at all events, a minor proof—that the three sensations which the eye distinguishes are green, blue, and red, and not yellow, blue, and red, as used to be thought. Here we have three colours rapidly rotating, and those three brilliant colours give the sensation of white. What proof is there in this that the three primary colours are red, blue, and green? Recollect that I showed you just now that blue and yellow made white, therefore red and green must make yellow. Is that the case? If that be the case, I think the point is proved. Let us see whether such is the case. We will go back to our apparatus consisting of the half-lenses. There is a reddish glass in front of one half-lens, green in front of the other half, the part of the discs which overlap is yellow; hence red and green make yellow. We have already seen that blue and yellow make white, but it takes red, green, and blue to make white; therefore yellow is equal to red *plus* green.

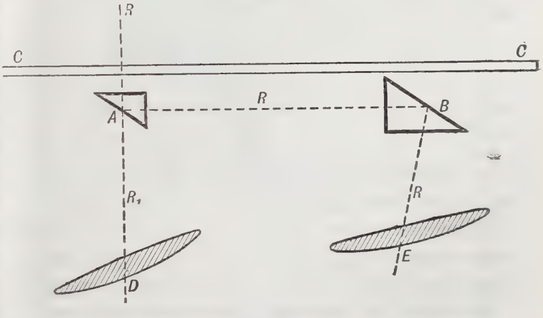
Let me further show this. I have a lens in front of the lantern which forms a slightly larger image of the aperture than before. Cemented alongside one another I have three coloured glasses—green, red, and blue. These, when placed in front of the lens, and in close contact with it, will, with a little manipulation, show a disc of light, something approaching white. The three colours combine to give this result.

I am next going to show you how we can get complementary colours. A patch of white light is now upon the screen by means of our much used apparatus. I have a card in which is cut a wide slot to allow the whole spectrum to pass through, and suspended from it is a little prism, which will cut off a certain amount of the spectrum. The part so cut off will be reflected on to a mirror, and by means of a lens will form a patch on the screen. The rest of the spectrum will go through to the lens, and form another patch of white minus the colour reflected. The two patches when superposed give white, but a rod placed in the front give two complementary colours side by side. The complementary colour is that which with the colour itself will give white. I will cut off the different parts of the spectrum, and you will see the real complementary colour. On cutting out the different colours you will notice I get almost every variety of hue, and the colours complementary to them. This seems a very simple way of getting complementary colours, and I think it is instructive, as at the same time it is seen that the background, where the two overlap together, is white.

The next point we come to is one that is very germane to our subject, and that is how are we to measure the intensity of pigments in any satisfactory way? As far as I know, a paper which General Festing and I recently read before the Royal Society explains the only method which has been satisfactory, so far, and I hope to show you how that is done.

The desideratum is to compare the intensity of any colour of the spectrum which is reflected from any pigment with that which is reflected from a surface of white paper. When you get that you know exactly the colour value of the pigment, and by certain methods which I shall show you bye-and-bye you can at any time make upon the screen without a pigment the exact colour of the pigment you have measured. In order to take these measurements it is necessary to have two similar spectra one above the other, and this we get in the following manner. Upon the screen a lens forms an image of an aperture placed in front of the lantern. Where the rays passing through the lens cross, I put what is known as a double-image prism, and by it we get two discs of light, which will rotate round a centre as the prism is turned round its axis. This double-image prism is of Iceland spar, made by Mr. Hilger with his usual ability. It gives us the means of at once getting two spectra one above the other having exactly the same quality of light.

Fig. 3.

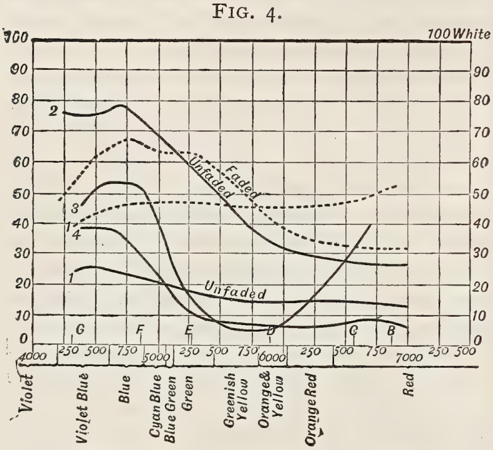


In contact with the lens of the collimator, as it is called (which makes the rays which strike the prism parallel), is placed the double image prism; we thus get two sets of

parallel rays, one set inclined at a slight angle to the other. Two spectra are formed by the prisms, one above the other, and separated by a breadth of about one-eighth of an inch. Passing a slit through those two spectra, the same colour is cut off from each when the double image prism is properly in adjustment. To the card, C, in which the slit is cut, two right-angle prisms are attached, as shown, and so adjusted that the beam, R, from the top spectrum is reflected first by the prism A, and then by the prism B, on to the screen. A lens, F, of about two feet focus, in front of B, makes a coloured patch on the screen, overlapping a patch of the same colour formed by the lens D, which comes from the bottom spectrum. By this means we get a parallax of lights of exactly the same colour, one from the bottom spectrum, and the other from the top spectrum. A rod placed in front of the patch will cast two shadows, one illuminated by one spectrum, and the other by the other. The colour which I propose to measure is on this card, one half of which is orange, and the other half white, and is surrouuded by a black mask. In the left hand shadow is the white card, and on the right hand is the colour which we wish to measure. In front of the beam which illuminates the shadow cast on the white surfaces are placed the rotating sectors, and by altering their aperture I can make the two coloured shadows of exactly the same intensity. Stopping the motor, the angular aperture is read off. With another part of the spectrum exactly the same thing is done; by that means we are able to compare the amount of light which is reflected for the pigment, and from the white card.

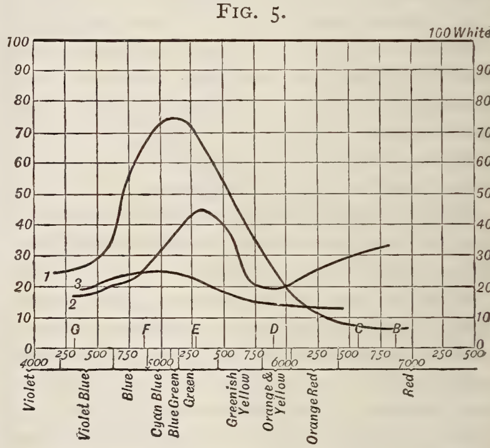
It is on this principle that these particular colours were measured. You will notice the

FIG. 4.



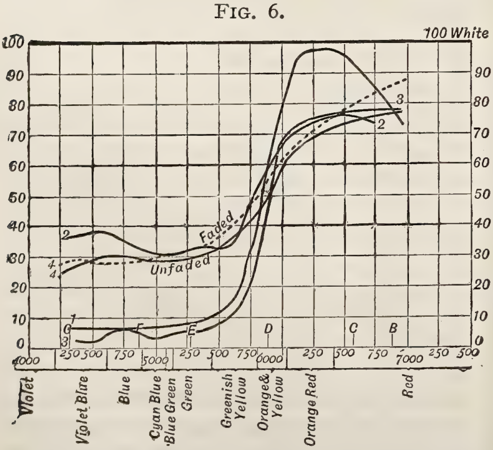
1. Indigo. 2. Antwerp Blue. 3. Cobalt. 4. French Ultramarine.

FIG. 5.



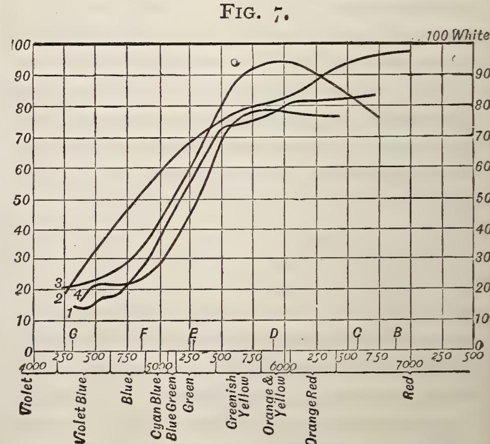
1. Emerald Green. 2. Chromous Oxide. 3. Terre Verte.

FIG. 6.



1. Vermilion. 2. Carmine. 3. Mercuric Iodide. 4. Indian Red.

FIG. 7.



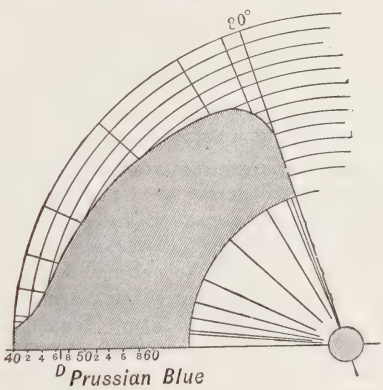
1. Gamboge. 2. Indian Yellow. 3. Cadmium Yellow. 4. Yellow Ochre.

peculiar curves which some of the colours on these diagrams give. Suppose, for instance, that for one spectrum to match the other in intensity throughout its length required an angular aperture of 100, and if for emerald green at a wave length of (say) 5,500, it required an angular aperture of 45, then in forming this curve we set off the wave lengths as a base line, and at 5,500 set up this angular aperture, which gives us a point on the curve, whilst the light reflected from the white surface is represented by 100. Thus, at this point, emerald green reflects only $\frac{45}{100}$ths of this particular light. By that means you are able to build up a curve, which is an absolute measure of the light reflected from the pigment, as compared with that reflected from the white surface. In the same way the other curves were constructed. I want you to notice how very peculiar are the curves of the yellow pigments. There seems to be very little difference in the intensity of light reflected from them, but when you see them they appear of decidedly different hues. It is just these little differences in the curves which make up the difference in the hues which are so noticeable to the artist's eye. Again, I want you to notice cobalt. You see what a large proportion of red there is in cobalt, and what a little red there is in Prussian blue or Antwerp blue. In indigo blue also there is very little red. Some people think there is a great deal of red in indigo, but really the red that you see comes from the violet end of the spectrum, and not the red end. So, in French ultramarine, there is a little amount of red reflected, but nothing worth speaking of. If we take a line tangential to the bottom of these curves, and parallel to the base line, the height of this tangent shows the amount of white light which is reflected from the pigment, and is a measure of its impurity. For instance, if you take the curve of cobalt, you will see it has about 3 per cent. of white light mixed with it; whilst in the tint measured of Antwerp blue there is about 23 per cent. of white light mixed with the true colour of that pigment. You will notice that, in all cases, a certain amount of white light is reflected from the pigments, and therefore not one is really a pure colour.

Now I want to show you another method, and one which has never been exhibited before, by which we can obtain the intensity of colours in a very simple way. I use for convenience sake a rather short focussed lens in the camera, as I want to form rather a bigger patch of white light. Behind those black discs of the motor is a disc of white card, and I am going to measure the intensity of spectrum colour reflected from a coloured disc by a novel method. I can put any coloured disc I like in front of the sectors, and in contact with them. I rotate the sectors in the coloured patch, and I can alter the amount of white on the larger disc until I get it to match the luminosity of the colour in the centre. Knowing how much black has to be mixed with white, in order to bring the tint reflected from the colour in the centre, and the same value as that reflected from the rotating black and white, I can readily determine the intensity of the light reflected. (Several colours were measured in succession, in the manner described.)

Next on my programme is the method of producing on the screen the exact colour of any pigment. The researches of Dr. Russell and myself on various pigments which have faded in light would be of little value, unless in, say, a thousand years' time those colours could be reproduced with the same accuracy with which they were measured. We have a means by which we can, without having the pigment itself, absolutely reproduce that colour from a card such as this. I will show you on the screen how it is done.

FIG. 8.



Prussian Blue

If we mark off the scale of the spectrum along the radius of a circle, and draw circles at the various points of the scale with the same centre, from the same centre can be drawn lines corresponding to the various angular apertures of the sectors required at the various points of the scale to measure the light reflected from a pigment. The point where one of these lines cuts the circle drawn through the particular point of the scale to which the aperture has reference, gives us a point on a curved figure,

which, when rotated in front of the spectrum in the proper position, will cut off exactly the right amount of the spectrum at each part of it to give the colour required. I will show you one or two of these colours, and by that means you will see that we have literally templates by which our successors in science will be able to reproduce the colours which we have measured in our experiments, and to see whether any alteration has taken place in those particular pigments we have used, and which we propose to leave, either at the South Kensington Museum or elsewhere, for the benefit of those who come after us. (The colours of various pigments of blue sky, gold, and gaslight, were reproduced on the screen.)

Whenever you measure any colour in sunlight, gaslight, starlight—whatever light it is —by cutting out templates like these, and in your laboratory carefully making the necessary adjustments, you can always reproduce on the screen any colour you may have measured, and if you use the light in which the colour has to be viewed to form the spectrum, you will get on the screen the colour as it would be seen in that light.

Miscellaneous.

PARIS EXHIBITION.

The following particulars respecting the British Section are taken from the *Times*:—

The preliminary arrangements for the British Section of the Paris Exhibition may now be said to be complete, the whole of the space originally placed at the disposal of the committee (rather more than 60,000 square feet, or about half the area occupied by Great Britain in 1878) having been either assigned to the few colonial commissions which have been appointed, or distributed among British exhibitors. Of these last there will be about 600. Compared with the numbers given as those of the exhibitors from foreign countries, this total may appear to be small; but it is quite as many as space can be found for. As Great Britain occupies the largest space of any foreign country in the Exhibition, it is evident that, in the case of other countries where a large number of exhibitors are crowded into a smaller area, either the exhibits themselves must be of an insignificant character, or they must be really collective exhibits, the number of each contributor being entered in the catalogue as an exhibitor.

It is expected that all the exhibits will be on the ground by the 1st of April, it being intended to devote the whole of that month to their arrangement and completion. It is probable that in many cases the time may have to be extended; but it is certain that the great bulk will have to be sent in not later than the end of March.

The important question of the transport of the goods has been for some time a matter of negotiation between the council of the section and the various railway companies, and it has been to a large extent delayed by the uncertainty of the companies as to the precise effect of the Railway and Canal Traffic Act, which came into action on the 1st of the present month. The French railways undertook to carry goods for the Exhibition at half rates, but neither they nor English lines in connection with them on this side see their way to making so large a deduction on the through rates between London and Paris. They, however, undertook to carry goods back from the Exhibition at half rates, provided full fare was paid on the outward journey, and it is now very probable that they will consent to modify this offer so far as to allow a deduction of 25 per cent. on each journey. Negotiations are in progress by which it is hoped to obtain this, or perhaps even a larger reduction, for the benefit of the exhibitors.

The question of the storage of empty cases has always been one of difficulty at Exhibitions. The council of the section, following the example of Sir Philip Cunliffe Owen in 1878, have obtained a piece of ground in close proximity to the Exhibition, on which suitable arrangements will be made for the storage of the cases, and it is intended that the charges to the exhibitors for this accommodation shall be less than the charges for which the contractor authorised by the French Executive undertakes to do the work. A circular giving information to exhibitors on these and other points of detail will be issued in the course of a few days.

For some time work has been proceeding in Paris in the principal courts of the section, and, indeed, we are more advanced than any other foreign nation, and quite as forward as the French themselves. The entrance to this court is by a large vestibule, which will be separated from the court itself by a handsome Elizabethan screen designed by Mr. Donaldson, one of the members of the council, the greater part of which is already in position. The decoration of the vestibule, as well as of the court itself, is a charge upon the section; as it will be remembered, the French Executive supply nothing but the bare walls and roof, not even the flooring. One principal feature of the decoration will be a series of panels in the roof, bearing the arms and names of the principal manufacturing towns which have contributed to the section; and the co-operation of the towns will be still further marked by a number of handsome banners which the corporations of most of them are having prepared for the purpose. At the other end of the British court is the space allotted to Belgium, divided from us by a broad gangway. Arches of a similar character to the screen at the end of the longitudinal

passages will mark the division. None of the other courts allotted to Great Britain are yet in a sufficiently forward state to allow of anything being done in the way of decoration. The structure of the great machinery hall is almost completed, but the end in which our section is placed, being the last to be finished, is as yet hardly ready for occupation. The same remark applies to the agricultural galleries, but the construction both of these and of the machinery gallery is not such as to require or to admit of a very large amount of decoration. Besides these there is a small space in the building known as the Palace of the Liberal Arts allotted to Great Britain; this also is not yet sufficiently finished to allow of any decorative work being done there; but the preparations for the decoration of all these courts are in hand.

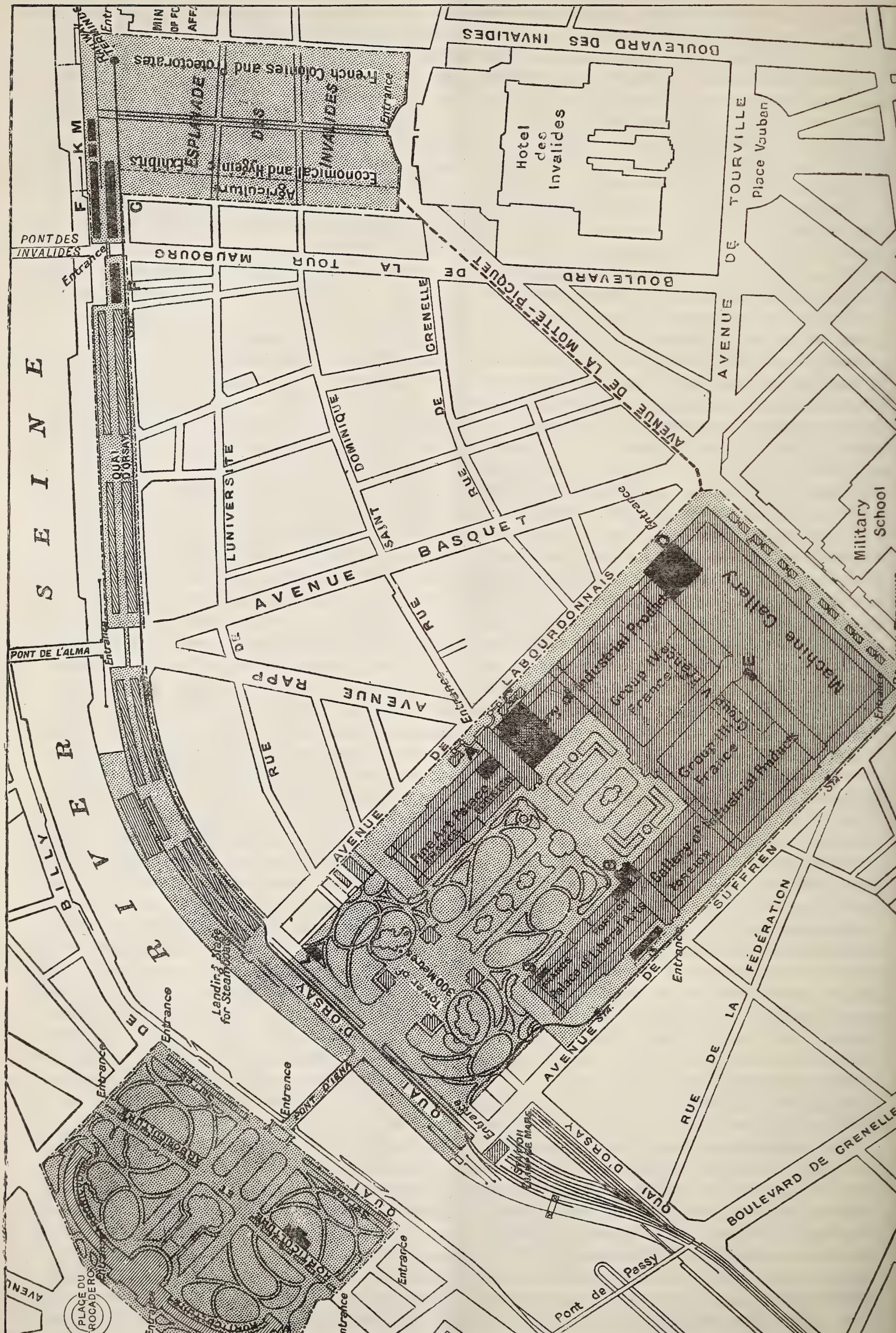
In addition to the buildings provided by the French Executive, the council of the section are erecting a handsome building, representing an Indian bazaar, or serai, in which the contributions from India will be placed. This building will form one of a range of Oriental structures running along the western side of the Champ de Mars, and will probably not be the least interesting of the collection. It will be 185 feet long and 45 feet wide. Its designer is Mr. Purdon Clarke, and it is intended to represent one of the old covered bazaars of the West of India, being, in fact, an imitation of a typical caravanserai. The style is that of the transition period between Pathan and Moghul, the details having all been taken from historical buildings. The decorations will be in plaster, cast direct from stonework originals now at South Kensington. The building consists of a long hall with a gallery on either side, the gallery being divided to form ten shops on each side. Seventeen out of the 20 shops have already been taken up by Indian exhibitors, and offers have been received from India for the remaining three. The front of the building consists of a large verandah forming an Indian tea bar. The payments for the rent of the shops—£100 each—and the amount paid by the Indian Tea Growers' Association for the right to sell Indian tea, provided the funds which will be required for the construction and maintenance of the building, so that it will be entirely self-supporting. In another part of the gardens a bar has been arranged for the sale of Ceylon tea. This will be managed by the Ceylon Tea Planters' Association. There will, therefore, be a satisfactory representation of the products of our Indian Empire.

The British colonies which will contribute to the Exhibition are Victoria, New Zealand, and the Cape. Quite a year ago negotiations were begun between the French Government and the Australian colonies, but for a long time the latter hung back, and indeed it was understood that they had definitely given up the idea of exhibiting. In consequence of this the council of the section were preparing to allot the space originally proposed for the colonies among British exhibitors. A few months ago, however, New Zealand expressed a wish to participate, and her example was soon followed by Victoria. The council accordingly gave up to these two colonies the colonial space, and on an application being received from the Agent-General of the Cape, gave up yet a further space for that colony. In addition to these, a position in the grounds has been obtained for an exhibit by the Kimberley Diamond Fields Company.

As now arranged, Victoria and New Zealand will both have a space in the General Industries Court, and they will also divide between them a gallery on the Quai d'Orsay, where the agricultural and food product exhibits are located. The Cape also will have the end of one of the British galleries on the Quai d'Orsay.

The Fine Arts Department has been a source of great difficulty. The industrial exhibits can very well afford to pay for themselves; but this is not to any large extent the case with pictures, most of which are borrowed from private owners. In 1878 a sum of £3,600 was spent in insurance of pictures alone. This is an item there is no getting over. Doubtless, to a certain extent, artists would be ready to send and insure their own pictures, as they do when they exhibit in the Salon; but for the bulk of the pictures funds must be provided to cover insurance and transport. It has been estimated that, however economically the work might be performed, at least £3,000 would be required for this purpose. Until the council could be sure as to what funds they would have at their disposal, of course no steps in this matter could be taken; but now that they are in a position to know almost precisely what their resources are, and to gauge with approximate accuracy the amount of their expenditure, they have come to the conclusion that they might fairly devote a small portion of the amount coming directly or indirectly from the industrial exhibits for the benefit of the Fine Art Section, seeing how greatly it would add to the interest of the section generally, and how distinctly it would redound to the credit of the country. They have also had regard to the fact that they have certain funds at their disposal for various concessions, so that they were able to devote at least £1,500 without trenching on the payments actually made by the exhibitors in the other sections. They hope that a similar sum will be made up by subscriptions, so that the amount of £3,000 may be available for the Fine Art Section. An earnest appeal is now being made by Sir Frederick Leighton, the chairman of the section, who is taking an active interest in it, to those interested in art in this country, for funds, and it is to be hoped that his appeal will be successful.

The accompanying sketch plan gives a general view of the buildings of the Paris Exhibition, with the positions of the different English courts. A shows the place which will probably be occupied by Great Britain in the Fine Art Palace; B is the British space in the Palace of the Liberal Arts; C is the principal British court in the Gallery of



RIVER SEINE
PONT DES INVALIDES
PONT DE L'ALMA
PONT D'IENA
Pont de Passy
QUAI D'ORSAY
QUAI DE BILLY
Landing Stage for Steamboats
ESPLANADE DES INVALIDES
French Colonies and Protectorates
Economical and Hygienic Exhibits
Agriculture
Hotel des Invalides
BOULEVARD DES INVALIDES
BOULEVARD DE LA TOUR MAUBOURG
AVENUE DE TOURVILLE
Place Vauban
AVENUE DE LA MOTTE-PICQUET
RUE DE GRENELLE
RUE SAINT DOMINIQUE
L'UNIVERSITE
AVENUE BASQUET
AVENUE RAPP
RUE DE
AVENUE DE LABOURDONNAIS
Military School
Machine Gallery
RAILWAY TERMINUS
Group VI. France
Group III. France
Gallery of Industrial Products
Fine Art Palace
Palace of Liberal Arts
Gallery of Foreign
Tower 300 Metres
AVENUE DE SUFFREN
RUE DE LA FÉDÉRATION
QUAI D'ORSAY
BOULEVARD DE GRENELLE
STATION CHAMP DE MARS
TROCADERO
PLACE DU TROCADERO
HORTICULTURE
Entrance

Industrial Products; D, the space in the Machinery Hall; E, the proximate position of the railway exhibits; F, the Agricultural Gallery; I, the Indian Palace; J, the Ceylon Tea House; K, model flour-mill, by Messrs. Robinson, of Oldham; M, model dairy, by the London and Provincial Dairy Association; L, the offices of the British Section.

SOUTH KENSINGTON FREE SCIENCE COLLECTIONS.

It was at the close of the exhibition of the loan collection of scientific apparatus at South Kensington in 1876 that the galleries west of the Horticultural Gardens became the home of the science collections of the Science and Art Department. Although they contain many objects of purely historic interest, and many apparatus specially designed and used in particular researches, the chief aim of the collections—to illustrate methods of science training in connection with the examinations of the Department—has all along been kept in view. During the years the collections have been in existence they have been largely consulted by teachers from all parts of the country, for among other advantages there are examples of the apparatus recommended by the Department for use in teaching the various "subjects," and these are exhibited by various English and continental makers, with some modifications in form and detail and some differences in cost. Every article thus shown has a label stating the maker's price. The cases containing apparatus made by pupils in the normal school of science are especially valuable to students working at home, as illustrating to them how they may make their own apparatus. Many teachers of London classes take their pupils to the collections on Saturdays, and they are not unfrequently visited by classes from the country.

From the time of their formation the collections have been slowly though steadily increasing, and at the commencement of last year the temporary displacement of the cases, consequent on the order for repairing and repainting the galleries, involved replacement, and the opportunity was taken to make the replacement to a great extent a re-arrangement.

The "subjects" in each of the upstair galleries are as formerly—Room I. Physiography and nautical astronomy. II. Geology and mineralogy. III. Chemistry. IV. Biology. V. Physics, with its divisions, sound, light, heat, magnetism, and electricity.

The ground floor, mechanics, &c., remains much as before, but in the upper galleries the alterations are numerous.

There being no catalogue or handbook, it may serve the useful purpose of drawing greater attention to our national science collections to mention some of the changes. The fact of there being no reference book hardly lessens their value to those who visit them, as everything is so fully labelled.

It may be mentioned that a visit now must be an intentional one. Up to about two months ago there was access to the galleries, from Naval Architecture Galleries, through the Buckland fish museum, and many of the general visitors from the art collections strayed in to them this way. The formation of the road in front of the Imperial Institute has, however, completely cut off the science collections, and the only entrance now is through the vinery in Queen's-gate.

It is in the Chemistry Gallery that the most striking alteration has been made, principally effected by Dr. Thorpe during the long vacation of the Normal School of Science. Seven spacious cases have been arranged as "Illustrations of the Alternative Systems for Stage I.—Inorganic Chemistry." Here Professor Thorpe has addressed himself directly to young students rather than to teachers, though teachers may take a suggestion of how to arrange a teaching collection in the museum of their own town. The characteristic feature is that the apparatus and requirements for each experiment illustrated, however "elementary," are shown put together and placed as in actual use. In some instances, the arrangement shows the experiment as it is about to begin; in others, when it is completed, the results obtained, where they are sufficiently permanent, being left. Clearly-printed cards, "To prepare ———;" or, "To show that ———, when mixed [or 'heated,' as the case may be] with ———, produces ——— [or such and such a change]. This, except for the attendant charms of smells and chances of small accidents, is a very near approach to watching an experiment performed. Nothing can of course take the place of a student actually performing an experiment himself; but for those who have not the opportunity this is an immense advantage over gaining ideas of experiments from illustrations in text-books. The need of chemical knowledge in nearly all our industries is being continually increasingly recognised, and seeing such a collection can hardly fail to arouse an interest in school children in a subject too often associated with ideas of dry and cabalistic text-books.

Other cases show requirements for the "advanced" classes, while for technical chemistry, such as in gas analysis, assaying apparatus, fat extractors, results of paraffin, &c., from bituminous shales, sulphur preparation, &c., there are selected examples. The latest addition in "research" chemistry is a Cailletet's apparatus for the liquifaction of oxygen.

In the illustrations of the practical bearings of entomology on agriculture, the "Insect Friends and Foes" (hung in cases on the walls of the south staircase) are being re-arranged, not as formerly, according to their zoological grouping, but botanically, that is, according to the plants or crops they affect.

In geology the principal additions are in relief

models and contour maps, and very complete illustrations of how to prepare rocks for microscopic examination. With the Jermyn-street Museum for practical geology and mining, and the Cromwell-road Museum embracing mineralogy, geology and paleontology, it has not seemed requisite to make additions here further than in their bearings on class work. Earthquake study is, however, illustrated by the newest form of seismograph made by the Cambridge Scientific Instrument Company.

In room No. 1, a large case has been added, illustrating chemistry in relation to physiography.

NEW RUSSIAN TEXTILE.

The French *Revue des Colonies* reports the discovery of a new textile on the shores of the Caspian. This plant, called *kanaff* by the natives, grows in the summer, and attains a height of ten feet, with a diameter varying from two to three centimetres.

By careful cultivation and technical manipulation, M. O. Blakenbourg, a chemist and engineer, who has made a special study of kanaff, has obtained an admirable textile matter; it is soft, elastic, and silky, gives a thread which is very tough, and can be chemically bleached without losing its value. The stuffs manufactured out of kanaff, and then bleached, can be successfully dyed in every shade of colour, and would compete with any of the ordinary furnishing materials now in use. But it is particularly for making sacks, tarpaulin, ropes, &c., that this new textile, from its cheapness, and its extraordinary resisting power, might defy all competition. Its specific weight is much less, but its resistance much greater those of hemp. Thus, a cord of 8·25 mm. diameter, woven with the hand out of three threads of kanaff, requires a weight of 180 kilogrammes to break it. A cord, half an inch thick, manufactured at Moscow, did not break till the weight of 625 kilogrammes was reached.

When it is considered that Russia annually consumes more than 150 millions of sacks, a third of which are imported, it may be easily seen that the appearance of this new textile on the Russian market is an event of no slight importance.—*Board of Trade Journal.*

DRUGS OF HONDURAS.

The medicinal and narcotic plants of Honduras have not received a great amount of attention, and but few are known. The *waika* (*Symphonia globulifera*) is the source of a medicinal resin, called *karamani*, which has also an industrial value. The pungent root of the horseradish tree (*Moringa pterygosperma*) may be used as a vesicant. Balsam of tolu, from *Myroxolon toluifera*, and balsam of copaiba, chiefly afforded by *Copaifera officinalis*, are collected in the interior of the country. The elastic gum (*balata*) of the naseberry or bully tree (*Achras sapota* [*Mimusops balata*]) is used as a masticatory in the United States. An infallible remedy for snake bite is provided by a twining plant called *guaco* (*Mikania guaco*), whose leaves are also employed as an anthelmintic and febrifuge. True ipecacuanha is replaced by a "bastard" sort called "red-head" (*Asclepias curassavica*). The juice of the *manzanillo* or manchineel (*Hippomane mancinella*), is so acrid and virulent as to rival in reputation the upas tree itself. The seeds of a forest tree, probably a *Piptadenia sp.*, are roasted by the Indians, powdered, mixed with lime, and taken like snuff, creating a peculiar kind of intoxication almost amounting to frenzy. A tree called *capoche* by the Indians affords "bitter cups," valuable for their antifebrile and anthelmintic qualities. The bark of the *cromanti* is another febrifuge, but less esteemed. A menispermaceous creeper, when reduced to powder, is employed in still pools for narcotising fish, which are then easily caught. The bark of the *carapa* (*Carapa guianensis*) is used as a febrifuge. A kind of copal exudes from the trunk of the locust tree (*Hymenæa courbaril*), and is found in lumps at the feet of old trees. A sort of gum-arabic is afforded by the *cashaw* (*Prosopis juliflora*).

Notes on Books.

THE STUDENT'S HANDBOOK OF ART; an Elementary History of Art. Painting. By N. D'Anvers. Third edition, revised and enlarged by Frank Cundall. London: Sampson Low, Marston, Searle, and Rivington.

This work, which is adopted by the Civil Service Commissioners as a text-book for the examination of candidates on questions of art, contains an outline of the history of painting from the earliest times, in which the peculiarities that may be looked for in the arts of different countries, and the various causes which have influenced the aims of painters of successive periods, are pointed out. The history of painting, as practised by the Egyptians, Greeks, and Romans, is lightly sketched before modern art, which began in the Middle Ages, is described. Special reference is made to the pictures of the National Gallery, so greatly improved of late years, but the editor draws special attention to the important fact "that a collection of moveable pictures can never do justice to those masters whose fame rests on their fresco paintings." These frescoes, of course, can only be seen in their original positions, but he also points out that the priceless collection of original drawings by the old masters in the British

Museum should be studied in connection with the history of painting.

The history is arranged according to schools and is brought down to the nineteenth century, and the volume ends with an account of painting in America. The true foundation of American art was laid by Copley and West, who afterwards came to England and made their great fame in this country. The work is fully illustrated with representations of the paintings of all schools and periods.

THE EDUCATIONAL ANNUAL, EDUCATIONISTS', SCHOOL-MANAGERS', AND TEACHERS' HAND-BOOK, 1889. Compiled by Edward Johnson. London: George Philip and Son.

This volume contains an account of the educational events of the year 1888, including a summary of the final report of the Royal Commission and of the Education Code, &c. It also contains information respecting elementary education, secondary schools and colleges, and technical education.

THE MINING MANUAL FOR 1858. By Walter R. Skinner. London.

The number of mining companies described in this work, without reckoning South African mines, is 900. The South African companies, which are treated of in a separate section, number 396. At the end of the alphabet of companies there is a list of mining directors.

ELEMENTARY COMMERCIAL GEOGRAPHY. A Sketch of the Commodities and the Countries of the World. By Hugh Robert Mill, D.Sc. Cambridge University Press. 1888.

The author has set himself the task of defining and illustrating the subject of commercial geography in a manner simple enough to be readily worked through in schools, and sufficiently accurate to serve for reference. The volume is clearly printed, and a large amount of information is put into a small compass.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings at Eight o'clock:—

JANUARY 16.—"The Channel Tunnel." By COLONEL HOZIER. SIR FREDERICK BRAMWELL, Bart., D.C.L., F.R.S., will preside.

JANUARY 23.—"Electric Meters for Central Stations." By PROF. GEORGE FORBES. W. H. PREECE, F.R.S., will preside.

JANUARY 30.—"The Construction of Photographic Lenses." By CONRAD BECK.

Papers for which no dates have as yet been fixed:—

"The Status of the County Council." By G. L. GOMME.

"The Forth Bridge." By BENJAMIN BAKER, M.Inst.C.E.

"Salt: its Production and Consumption at Home and Abroad." By PETER LUND SIMMONDS, F.L.S.

"The Manufacture of Aluminium." By WILLIAM ANDERSON, M.Inst.C.E.

"Automatic Selling Machines." By J. G. LORRAIN.

"Secondary Batteries." By W. H. PREECE, F.R.S.

"Arc Lamps and their Mechanism." By Prof. SILVANUS P. THOMPSON.

"The Irish Lace Industry." By ALAN S. COLE.

"The Use of Spirit as an Agent in Prime Movers." By A. F. YARROW.

FOREIGN AND COLONIAL SECTION.

Tuesday evenings, at Eight o'clock:—

JANUARY 29.—"Gold Mining in Colorado." By THOMAS W. GOAD.

FEBRUARY 19.—"Slavery in its relation to Trade in Tropical Africa." By Commander V. LOVETT CAMERON, C.B., R.N.

MARCH 12.—"Borneo." By ROBERT PRITCHETT.

APPLIED ART SECTION.

Tuesday evenings, at Eight o'clock:—

JANUARY 22.—"Some Recent Movements in Relation to the Applied Arts." By SIR JAMES D. LINTON.

FEBRUARY 5.—"Manufacture of Sèvres Porcelain." By EDOUARD GARNIER.

FEBRUARY 26.—"English Bookbinding in the Reign of Henry VIII." By W. H. J. WEALE.

MARCH 19.—"The Art of the Jeweller." By CARLO GIULIANO.

APRIL 9.—

MAY 14.—"Venetian Glass." By DR. SALVIATI.

INDIAN SECTION.

Friday evenings, at Eight o'clock:—

JANUARY 25.—"The Trade of India and Persia with East Africa, past and present." By H. H. JOHNSTON. MAJOR-GENERAL SIR FREDERICK J. GOLDSMID, K.C.S.I., C.B., will preside.

FEBRUARY 15.—"The Progress of the Railways and Trade of India." By SIR JULAND DANVERS, K.C.S.I.

MARCH 8.—"The Present Condition and the Prospects of Indian Agriculture." By PROF. ROBERT WALLACE.

MARCH 29.—

MAY 3.—"The Karun as a Trade Route." By MAJOR-GENERAL SIR R. MURDOCH SMITH, K.C.M.G.

MAY 24.—"Indian Wheats." By JOHN McDOUGALL.

CANTOR LECTURES.

The following courses of Cantor Lectures will be delivered on Monday evenings at Eight o'clock:—

ALAN S. COLE, "Egyptian Tapestry and Textiles." Two Lectures.

LECTURE I.—JANUARY 21.—Textiles discovered at Akhmîm in Upper Egypt—Varieties of patterns in them, showing successive influences—Greek—Græco-Roman—Syrian—Christian-Coptic; Sketch of Egyptian intercourse with foreign countries from end of 26th (Saite) dynasty to Arab invasion 7th century A.D.; Simple weaving in Egypt—Shaggy-faced textiles compared with the Greek *Kaunakes* and Roman *Gausapum* — Embroidered linens; Tapestry-weaving process described by Ovid, and used by inhabitants of Akhmîm for decoration of costumes—Corresponding use of same process by natives of Peru during the Inca Empire—Silk specimens from Akhmîm.

LECTURE II.—JANUARY 28.—Complete robes and clothes found at Akhmîm compared with tunics of early Egyptians, of Hebrews and Syrians—Greek and Roman tunics—Ornamental bands, &c., on Akhmîm tunics—Various shapes of bands or *clavi*, of squares and roundels, *tabulæ adjunctæ*, and *caliculæ* compared with costumes shown in the wall paintings of Roman catacombs—Ravenna mosaics of Empress Theodora, &c.—Typical ornaments from Akhmîm compared with similar motives at Kermanchah—Persepolis—Cyprus—and in Roman mosaics from Constantine, Algeria — Barcelona, Spain; Christian symbols—Byzantine styles—Conclusion.

W. J. LINTON, "Wood Engraving." Two Lectures.

February 11, 18.

WALTER CRANE, "The Decoration and Illustration of Books." Three Lectures.

March 4, 11, 18.

C. V. BOYS, F.R.S., "Instruments for the Measurement of Radiant Heat." Four Lectures.

March 25; April 1, 8, 15.

H. GRAHAM HARRIS, M.Inst.C.E., "Heat Engines other than Steam." Four Lectures.

May 6, 13, 20, 27.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, JAN. 14...Surveyors, 12, Great George-street, S.W., 8 p.m. Adjourned discussion on Mr. A D. Wells's paper, "The Prospects of an Agricultural Revival."
British Architects, 9, Conduit-street, W., 8 p.m.
Medical, 11, Chandos-street, W., 8½ p.m.
London Institution, Finsbury-circus, E.C., 5 p.m. Mr. W. St. Chad Boscawen, "Recent Babylonian Explorations."

TUESDAY, JAN. 15...Civil Engineers, 25, Great George-street, S.W., 8 p.m. Discussion on Mr. Edgar Worthington's paper "The Compound Principle as applied to Locomotives."
Statistical, School of Mines, Jermyn-street, S.W., 7¾ p.m.
Pathological, 53, Berners-street, Oxford-street, W., 8½ p.m.
Zoological, 11, Hanover-square, W., 8½ p.m. 1. Rev. O. P. Cambridge, "Some New Species and a New Genus of Araneidea." 2. Prof. F. Jeffrey Bell, "Additions to the Echinoderm Fauna of the Bay of Bengal." Mr. F. E. Beddard and Mr. Frederick Treves, "The Anatomy of *Rhinoceros lasiotis*."
Colonial Institute, Whitehall-rooms, Hôtel Métropole, Whitehall-place, S.W., 8 p.m. Mr. H. H. Johnston, "British West Africa and the Trade of the Interior."

WEDNESDAY, JAN. 16...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Colonel Hozier, "The Channel Tunnel."
Meteorological, 25, Great George-street, S.W., 7 p.m. Dr. W. Marcet (president) address on "Fogs," illustrated by lantern slides.
Entomological, 11, Chandos-street, W., 7 p.m. Annual Meeting.
Archæological Association, 32, Sackville-street, W., 8 p.m.
Inventors' Institute, 27, Chancery-lane, W.C., 8 p.m. Mr. F. M. H. Jones, "Silicate Cotton as a Fire-proofing Material."

THURSDAY, JAN. 17...Fröebel Society (at the HOUSE OF THE SOCIETY OF ARTS). 10 a.m., Conference of Kindergarten Teachers. 8 p.m., Annual Meeting. Paper by Miss Sherreff, "The Relation of Fröebel to Slöyd and Technical Education."
Royal, Burlington-house, W., 4½ p.m.
Antiquaries, Burlington-house, W., 8½ p.m.
Linnean, Burlington-house, W. 8 p.m.
Chemical, Burlington-house, W., 8 p.m. Ballot for the Election of Fellows. 1. Messrs. M. M. P. Mim, and Arthur Hutchinson, "A Cubical Form of Bismuthous Oxide." 2. Mr. Douglas Carnegie, "The Iodides of Copper." 3. Mr. C. W. Kimmins, "The Periodates." No. II.
London Institution, Finsbury-circus, E.C., 6 p.m. Mr. Edmund Gosse, "The English Novel in the 17th century."
Historical, 11, Chandos-street, W., 8½ p.m.
Numismatic, 4, St. Martin's-place, W.C., 7 p.m.

FRIDAY, JAN. 18...Philological, University College, W.C., 8 p.m. A Dictionary evening by Mr. Henry Bradley, with a Report from Oxford.

Journal of the Society of Arts.

No. 1,887. Vol. XXXVII.

FRIDAY, JANUARY 18, 1889.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

SWINEY PRIZE.

The adjudicators under the will of the late Dr. Swiney are summoned to meet on Monday, the 21st inst., at 4 p.m., to make the award in conformity with the terms of the bequest contained in the will of the testator.

By order,

H. Trueman Wood,

Secretary.

UNION OF INSTITUTIONS.

The following Institution have been received into Union since the last announcement:—

Norwich Insurance Institute, Norwich.

Proceedings of the Society.

CANTOR LECTURES.

LIGHT AND COLOUR.

By Captain W. De W. Abney, C.B., F.R.S.

Lecture IV.—Delivered Dec. 17, 1888.

We have, in the three preceding lectures, seen how colour is produced, and how it depends on three factors—the kind of light falling on to the substance, the kind of substance itself, and also the eye of the observer.

To-night I have to endeavour to explain in one hour what ought to take four hours, and to show you how light acts in altering the colour of pigments through what I may call mechanical means. A water-colour picture (I shall deal only with such) is exposed in the ordinary atmosphere of a room. Sometimes that room is without a fire; consequently the atmosphere becomes more or less damp, and all absorbent objects take up moisture. At other times, when there is a certain amount of warmth, the moisture which the picture would take from the air is less; so that a picture is exposed to alternations of damp and dryness. Dr. Russell and myself concluded that it would be quite fair for testing the stability of water-colour pigments if we exposed them to the ordinary outside atmosphere, and then traced the amount of fading which took place, remembering this, that a picture inside a room would certainly be more stable, supposing moisture had anything to do with fading.

We prepared tubes, as in Fig. 1, perfectly open at each end, but with a small cork in the unbent end, the cork being pierced with a

Fig. 1.

large hole. A current of air could pass throughout the tube when hung on a bar by the bend and exposed to the sunlight. Inside each tube were strips of paper, covered with a pigment which had been tinted by hand in graduated tints (such as you see here). There were eight tints in all. One such strip was placed in one end of the tube and another in the other. The lower half of the tube was covered with an opaque covering so as to protect it entirely from the light, and the other was left free to the sunlight. By-and-by I shall show you why it was we deliberately chose sunlight to which to expose our water colours. From theoretical considerations we arrived at the conclusion that fading would take place in a shorter time in sunlight than it would do if we exposed it to the open sky alone.

In such a series of tubes, containing in all somewhere about 100 colours—39 being simple colours, the others being mixed colours—were exposed. The first reading of the amount of fading was taken in August, 1886, or after four months' exposure, and we found that in many of the colours fading had taken place to a certain extent, although perhaps not to so large an extent as might have been anticipated. From time to time after that date the

tubes were examined, and the amount of fading noted, our notes showing the deepest tint which was visibly acted upon. Finally, we were obliged to conclude our experiments, owing to the impatience of certain gentlemen who were anxious to get the results we had obtained, apparently for their own advantage rather than for that of the public. We thus stopped our first series of experiments in March of this year, or after these tubes had been exposed about one year and nine months outside my laboratory at South Kensington.

In these tubes, then, we had the ordinary atmosphere, to which moisture and air had free access. If the tube got the least bit heated a current passed through it, much in the same way as would be the case in a chimney. The great point to settle was whether the fading which we knew must take place, and which we subsequently noted, was due to the air itself, or to the air *plus* moisture, or to the moisture alone. In order to test that, we passed air over various drying materials, dried the papers and tubes very thoroughly. The papers were then placed in straight tubes sealed at one end, and when filled with dry air the other end was sealed off, and they were exposed to sunlight, one paper being shaded from it as before. In the case of the open tubes, we found out of 39 simple colours only 12 were not acted upon; and in Table I. you have the 39 single colours in the order of their fugitiveness.

TABLE I.

Carmine.	Permanent blue.	
Crimson lake.	Antwerp blue.	
Purple madder.	Madder lake.	
Scarlet lake.	Vermilion.	
Payne's grey.	Emerald green.	
Naples yellow.	Burnt umber.	
Olive green.		
Indigo.		
Brown madder.	Yellow ochre.	Show no change.
Gamboge.	Indian red.	
Vandyke brown.	Venetian red.	
Brown pink.	Burnt sienna.	
Indian yellow.	Chrome yellow.	
Cadmium yellow	Lemon yellow.	
Leitches blue.	Raw sienna.	
Violet carmine.	Terre verte	
Purple carmine.	Chromium oxide.	
Violet carmine.	Prussian blue.	
Purple carmine.	Cobalt.	
Sepia.	French blue.	
Aureolin.	Ultramarine ash.	
Rose madder		

Vermilion is ordinarily supposed not to change at all, but, as a matter of fact, it does change, and in every sample there has been a little blackening. Those last on the list, yellow ochre, Indian red, and so on, show no change whatever after being exposed to as much sunlight as there was in one year and nine months. They remained perfectly unaltered, and, if you begin with rose madder (all below which may be said to be practically permanent) you have a very good gamut on which an artist could work in water colour.

In the closed tubes with dry air, out of thirty-eight sample colours which were exposed, twenty-two were not acted upon, so that it is evident that moisture had something to do with the fading of some.

TABLE II.

Name of Colour.	Dry Air.
Carmine	Faded to 7.
Crimson lake	Gone to 5.
Scarlet lake	Faded and darkened.
Vermilion	Gone black.
Rose madder	No change.
Madder lake	No change.
Indian red	No change.
Venetian red	No change.
Brown madder	Faded to 4.
Burnt sienna	No change.
Gamboge	Faded to 3.
Aureolin	No change.
Chrome yellow	No change.
Cadmium yellow	No change.
Yellow ochre	No change.
Naples yellow	No change.
Indian yellow	Faded to 4.
Raw sienna	No change.
Emerald green	No change.
Terre verte	No change.
Chrom. oxide	No change.
Olive green	No change.
Antwerp blue	Faded to 3.
Prussian blue	Faded to 5.
Indigo blue	Faded to 7.
Cobalt blue	No change.
French blue	No change.
Ultramarine ash	No change.
Leitches blue	Faded to 5.
Permanent blue	No change.
Payne's grey	No change.
Violet carmine	Faded and brown.
Purple carmine	Faded.
Purple madder	Faded to 4.
Sepia	No change.
Vandyke brown	V. sl. faded.
Burnt umber	No change.
Brown pink	Faded to 4.

NOTE.—Sl. means slightly; V. sl. means very slightly; No. 1 is the faintest tint.

The next series was interesting. The same kind of tube was taken and filled with hydrogen, and also with as much moisture as the hydrogen and paper would take up. The tubes were then sealed and exposed to light approximately for the same length of time as the other tubes. As a matter of fact, out of thirty-six colours twenty-two remain unchanged, the same as before. Hydrogen, I may say, is partially an inert gas for this purpose, as we proved subsequently.

Then we come to the most interesting series of all, when we excluded air and moisture from the water colours. We took exactly similar tubes, dried the papers very carefully indeed, dried the tube, inserted the papers, put a Sprengel pump to work, and made a vacuum, and then when the vacuum was very complete, sealed off the top and exposed them.

TABLE III.

Name of Colour.	Vacuum.
Carmine	No change.
Crimson lake	No change.
Scarlet lake	No change.
Vermilion	Gone black.
Rose madder	No change.
Madder lake	No change.
Indian red	No change.
Venetian red	No change.
Brown madder	No change.
Burnt sienna	No change.
Gamboge	No change.
Aureolin	No change.
Chrome yellow	No change.
Cadmium yellow	No change.
Yellow ochre	No change.
Lemon yellow	No change.
Naples yellow	No change.
Indian yellow	No change.
Raw sienna	Sl. darkened.
Emerald green	No change.
Terre verte	No change.
Chrom. oxide	No change.
Olive green	No change.
Antwerp blue	No change.
Prussian blue	V. sl. faded.
Indigo blue	No change.
Cobalt blue	No change.
French blue	No change.
Ultramarine ash	No change.
Leitches blue	No change.
Permanent blue	No change.
Payne's grey	No change.
Violet carmine	Sl. darkened.
Purple carmine	Sl. darkened.
Purple madder	V. sl. gone.
Sepia	Sl. faded to 6.
Vandyke brown	No change.
Burnt umber	No change.
Brown pink	No change.
Indian yellow and rose madder	No change.
Rose madder and raw sienna	No change.
Raw sienna and Venetian red	No change.
Vermilion and chrome yellow	More yellow.
Burnt sienna and Naples yellow	V. sl. faded.
Indigo, Indian yellow, raw and burnt sienna	No change.
Indigo and gamboge	Gone blue.
Prussian blue and gamboge	Gone green.
Burnt sienna and Antwerp blue	Gone red.
Raw sienna and Antwerp blue	Gone brown.
Prussian blue, raw and burnt sienna, and Indian yellow	Gone brown.
Prussian blue and burnt sienna	Gone brown.
Indigo and Vandyke brown	Faded.
Prussian blue and burnt sienna	Gone brown.
Prussian blue and raw sienna	Gone red.
Indigo and raw sienna	No change.
Indigo and burnt sienna	No change.
Indigo, raw and burnt sienna	No change.
Prussian blue and Vandyke brown	Gone brown.
Indigo and Venetian red	No change.
Prussian blue and Indian red	Gone red.
Indigo and Indian red	No change.
Prussian blue and crimson lake	Gone pink.
Antwerp blue and crimson lake	Gone pink.
Indigo, Venetian red, yellow ochre	No change.
Prussian blue, yellow ochre, Venetian red	Gone red.

NOTE.—Sl. means slightly; V. sl. means very slightly; No. 1 is the faintest tint.

We here arrived at the very interesting fact that out of thirty-nine simple colours which were exposed, only five were acted upon in the very least, and the amount of change was so slight that you might almost say every colour remained perfectly unchanged in vacuo. The five that were changed were vermilion (which went black to a very slight extent), raw sienna, Prussian blue, purple madder, and sepia. We are apt to look on sepia as one of the most permanent pigments; as a matter of fact it is fugitive, and those who have examined sepia drawings made in the early part of the century will see there has been certainly a distinct fading of those drawings. By the process of exhaustion, we arrived at the fact that it requires both moisture and air to cause the fading of these pigments.

Now the question arose—Would heat without light cause the fading of pigments? Where they were exposed to sunlight it might be surmised, perhaps fairly, that in the sunlight, which we know has a heating effect, the fading might be due to this cause in the open tubes.

This could not be the case in the closed

tubes, as in them the colours did not fade. To test the action of heat alone, we took tubes in which the papers were sealed up with moist air, and exposed them for three or four weeks, at the temperature of boiling water, in the dark. There was a certain amount of fading in these colours, but I need scarcely say that the fading was small, and also that the temperature to which they were exposed was something far beyond that to which colours in our open tubes were subjected. If you put a thermometer up one of the open tubes when it is in full sunshine, the difference between the temperature of the air inside it and the air outside only varied between three and four degrees. That was simply due to the fact that there was a draft created up the tube, as already pointed out.

But another point, and a very fair point for the critics to take hold of, is this. It is all very well to say light alone causes fading, but how about light and heat together, would not the heat aid the light? This possible criticism was combated, I hope, in a successful way. A certain series of pigments were taken and exposed on a vessel containing boiling water; another similar paper was exposed to the sunlight free, that is to say, without the presence of the boiling water. In some few cases the fading was rather more rapid, in others less, and you will very readily see why, in some cases it was rather less rapid. You require moisture *plus* air in order to cause fading, and if you heat the paper of course you take away part of the moisture—one of the agencies which are conducive to fading. But the difference between those exposed on boiling water, and those exposed without, was so small that you might take the action of light *plus* heat as equivalent to the action of light alone.

There was another experiment we had to try, and that was which were the rays which caused the fading. I have shown you in my previous lectures that beautiful band of colour we call the spectrum. I daresay you noticed that the beam of light which passes through the slit to form the spectrum is uncommonly narrow; for accurate experiments we should not use it more than 1-1000th inch wide, and that has to be spread out into that band of colours, so that really the light which strikes upon the screen is very feeble indeed. If we had attempted to expose some of these pigments in the spectrum, we should have had to expose them for some thousands of years, and as life is shorter than this, we thought it was better to take some other means of arriving at the conclusion as to what coloured rays were the active agents; so we adopted a method which, perhaps, may be called crude, but I do not think it is crude when you know how you are going to work. We exposed slips of paper beneath coloured glass—red, blue, and green, and also white. Here are some of the pigments which were actually exposed. We got the results as shown in Table IV. (p. 117).

We exposed 39 or 40 simple colours besides compound colours, and I want you to notice how very few faded in the green, in the red less than the green, but a very great many more under the blue glass than under either of the other two, You will see that the blue and the white were almost equally effective. Had a certain proportion of the blue rays in the white light been cut off by the glass, practically those two columns, white and blue, would have been identical. Under the red and green glasses the fading of the few pigments which succumbed was so small that it required a practised eye to distinguish it.

Now I will read you some conclusions we came to with regard to the fading of water colours:—"Mineral colours are far more stable than vegetable colours, and amongst those colours which have remained unaltered, or have very slightly changed after an exposure to light of extreme severity, a good gamut is available to the water-colour artist. The presence of moisture and oxygen are in most cases essential for a change to be effected, even in the vegetable colours. The exclusion of moisture and oxygen, particularly when the latter is in its active condition, as experiments to be described in our next report show, would give a much longer life even to these than they enjoy when freely exposed to the atmosphere of a room. It may be said that every pigment is permanent when exposed to light in *vacuo*, and this indicates the direction in which experiments should be made for the preservation of water-colour drawings. The effect of light on a mixture of colours which have no direct chemical action on one another is that the unstable colour disappears, and leaves the stable colour unaltered appreciably. Our experiments also show that the rays which produce by far the greatest change in a pigment are the blue and violet components of white light, and that these, for equal illumination, predominate in light from the sky, whilst they are less in sunlight and in diffused cloud light, and are present in comparatively small proportion in the artificial

TABLE IV.

	White.	Blue.	Green.	Red.
Purple Madder......	Faded to 2	Faded to 1	—	—
Antwerp Blue	No experiment	Faded	—	—
Leitches Blue	Sl. faded	Sl. faded	Darkened ..	Darkened
Violet Carmine......	Faded to 1	Faded to 1	—	—
Payne's Grey	Faded to 1	Bluer	Blue	—
Indigo	No experiment	Faded to 1	—	Sl. faded.
Prussian Blue	No experiment	Sl. faded	—	V. sl. faded.
Rose Madder ...... (2 experiments.)	Sl. bleached	Sl. faded	—	—
Brown Pink	No experiment	Faded to 3	—	—
Crimson Lake	No experiment	Faded	Sl. faded ..	Sl. faded.
Vandyke Brown	No experiment	Faded to 1	Sl. faded ..	—
Vermilion	Darkened	V. sl. darkened	—	—
Carmine	No experiment	Faded to 3	Sl. faded ..	—
Gamboge	No experiment	Faded to 1	—	—
Indian Yellow	No experiment	No change	—	—
Sepia	Become lighter	Become lighter	—	—
Burnt Sienna........	No change	No change	—	—

COLOURS MIXED WITH CHINESE WHITE.

	White.	Blue.	Green.	Red.
Antwerp Blue	No experiment	Bleached	—	—
Prussian Blue	No experiment	Bleached	—	—
Purple Madder......	Bleached	Bleached	—	—
Burnt Sienna........	No change	No change	—	—
Gamboge	No experiment	Sl. bleached	—	—
Indian Yellow	No experiment	Sl. bleached	—	—
Vandyke Brown	No experiment	Bleached	—	—
Brown Pink	No experiment	Bleached to 3	—	—
Crimson Lake	No experiment	Bleached to 3	—	Sl. faded.
Carmine	No experiment	Bleached to 3	—	—
Vermilion	Blackened	Blackened under 1 and 2	—	—
Rose Madder	Sl. bleached	V. sl. bleached	—	—
Violet Carmine......	Bleached to No. 1 and darkened to 2 and 3	Same as under white glass	—	—
Payne's Grey	Bleached to 1	Become bluer	Become bluer	—
Sepia	Lighter............	Lighter............	—	—

NOTE.—Sl. means slightly; V. sl. means very slightly; No. 1 is the faintest tint.

lights usually employed in lighting a room or gallery."

Now, it has been said that moisture and oxygen are essential for the fading of water-colour pigments. Is it possible that they can fade without light? I think here we have an absolute proof that such is possible. I have here a stream of oxygen passing through this tube in which are some papers coated with pigments; half of each paper has been damped and the other half is dry. In connection with this tube is an ozone generator, and a Ruhmkorff coil produces ozone, or the active state of oxygen, which is said to be particularly present near the sea. In this frame [shown] you have a series of colours which have been exposed to moist ozone. A great many are bleached entirely, thus proving, if you have ozone and moisture together, you get a bleaching without the presence of light at all. Here are some papers which were exposed to moist ozone before the lecture, and you will be able to see the amount of fading that has taken place. I think they were exposed for about ten minutes. In the example of indigo the bottom part was damped and the top part left dry; the first half has faded, the other has not. In carmine, too, you will see that where it has been damped the colour has entirely gone; the dry part is much less changed. We come then to the conclusion that oxygen and moisture are sufficient for the fading of water-colour pigments, and that it is not absolutely necessary that there should be light present in order that this fading may take place. Now, as before said, you are supposed to have more ozone at the seaside than inland. It is therefore a matter for consideration whether it may not be the fact that water-colour drawings fade more rapidly near the sea, where there is more ozone present, than they would do inland. That is a question I am not going to touch upon now, but when we make a subsequent report no doubt that will be brought forward prominently.

We have seen the results of light, and I wish to show you how it is that light acts upon matter. Matter is formed by molecules, or very minute particles, far beyond the vision of the best microscope that was ever made; you can only reason and argue about them from the circumstantial evidence which nature from time to time puts before us. The molecules themselves are composed of atoms. Thus, in the molecule of water it is supposed there are two atoms of hydrogen and one of oxygen. Each molecule is presumably of identical shape, and size, and composition. There has been a certain amount of evidence brought forward that perhaps some molecules of the same kind of matter are rather bigger than others, but to my mind such evidence is incomplete, and I cannot accept it. At any rate, as a rule, we may take it that the size of the molecule is the same for the same species of matter; that, for instance, all water molecules are the same size and composition as are those which go to form the molecules of these pigments we are considering.

I want to give you a homely notion of what a molecule is like, and how we may suppose the atoms vibrate. I have here a little cell of water, through which a beam of light can be thrown. Around this cell of water I can cause a current of electricity to pass through a coil of wire. When you have a current passing there is a certain amount of magnetism produced which repels magnetism o the like kind. I have here some little needles which are magnetised, and inserted in small bits of cork by one end, the same poles being in the corks. The corks will float on the surface of the water, thus supporting the needles. Now, if we float some of these little magnets in the water, they will repel each other and tend to go farther apart, the reason being that magnetism of the same kind repels. Now if I turn on the current in the wire passing round the cell you will see that they are found to approach one another, and as I move the wire up and down, they alternately approach to and recede from one another.

You must recollect that at the same time that these atoms are vibrating one towards the other, the molecules themselves are vibrating to and fro from one another, so that we have vibrations of the molecule and vibrations of the atom. Now I have told you that the waves of light vary in length; the red waves are the longest, and the blue waves are the shortest, and as they all travel at the same speed, the time of oscillation of the red wave is longer than the time of oscillation of the blue wave. We may take it that the oscillation of a molecule is slower than that of an atom, and it is much more likely to be isochronous with a wave of red light than it would be with one of blue light. Similarly, the waves of blue light are much more likely to be isochronous with the time of oscillation of the atoms than the molecules, and, as a matter of fact, such we find to be the case.

Now let me give you another homely example

of what we mean by oscillation on the part of an atom or a molecule. You can quite understand, I think, that if you have a body oscillating to and fro from another body, both of which attract one another, if you increase the oscillation, a time comes when the attraction between the two is so small that there is a great tendency for them to fall apart. If there is another body at hand which is willing to take up one of those atoms—which has a great affection for such atom—it will take hold of it, and bring it to itself. The bob of this pendulum, which is of iron, is supposed to be an atom swinging, and behind it there is a magnet. By blowing at the same rate as the pendulum vibrates I can increase the amplitude of that oscillation until I get up a swing so great that, eventually, the attraction of the magnet for the bob of the pendulum is greater than the force of gravity, and it reaches the magnet and is held by it. This very simple experiment teaches us a lesson. Here we have an atom swinging away, we will suppose, from another atom of something. My breath timing itself with the swing may be taken as the oscillation of a ray of light. The wave of light perpetually beating on the atom will increase the amplitude of swing of that atom so greatly that if there is another body near it which will take up the atom, it leaves the original atom for it. When such a re-arrangement of atoms takes place, we say that a chemical action has taken place, that is, that light is able to decompose a molecule by robbing it of some of its atoms, and giving them to another body. We get, then, by the decomposition new molecules formed, and consequently new matter, and such a new body may be in the shape of a faded pigment.

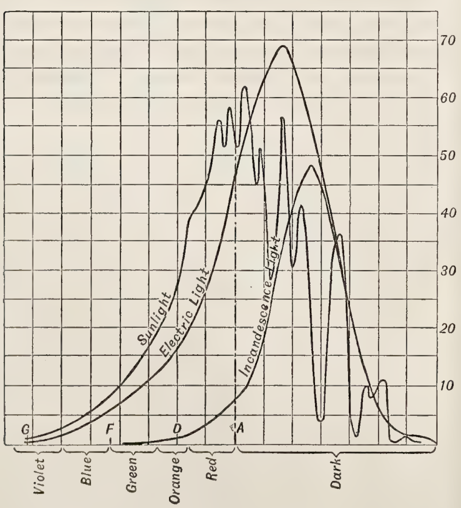
Throwing a spectrum on the screen, I put a layer of pigment in front of the slit, the light passes through it, and we get, as you saw by previous experiments, some colour taken away from the white light, and other colours left behind. In the case before us the red and the green and the blue are left, but most of the green is cut off. I will put another substance (permanganate of potash) in front, which gives a beautiful absorption spectrum, and there are a number of dark bands in it. If I take the iron salt which I used in the experiment in measuring the quantity of light which came to galleries of South Kensington, you see that it cuts off the blue almost entirely. You can see, then, that these various solutions cut off a certain amount of colour from the spectrum. Now the question is this, what becomes of the rays that are cut off? The whole principle of the chemical action, and the heating effect of light upon pigments, is answered by the answer to that question. It is this. Where you have an absorption of light, there you have work done upon the body on which it falls. In that permanganate of potash, for instance, which you saw gave a fine spectrum—the rays missing, which gave the black spaces, were doing work on it. They were heating up the permanganate of potash, or chemically changing it into something else. You cannot have work done on any body unless there is absorption by that body. You understand what I mean by absorption—the cutting off the light by the body. When there is chemical action taking place, the work done is the swinging the atoms away from each other, when heating effect takes place the molecules are swung further apart from one another. I hope I have made clear to you that my view is that when you have chemical action taking place, the absorption takes place in the atoms; when it is a heating effect which takes place, it is the molecules which are acted upon, and made to jostle each other more vigorously. As far as chemical action is concerned we have a very familiar example in photography. I am going to develop a spectrum for you. This has been done before in this room by myself, but as there are many here who have not seen the experiment, I think it might be as well to repeat it. [The photograph of the spectrum was developed.] The paper was covered with bromide of silver, and if I place a slab of bromide of silver in front of the slit, you will see that the absorption exactly agrees with the locality where chemical action has taken place.

Now I have another experiment to show you, and that is the heating effect of radiation. I have here a little instrument called a thermopile which consists of strips of two metals soldered together at one end. If the junction be heated, a current of electricity will pass through wires attached to the other ends when joined; and if a galvanometer is in the circuit the galvanometer needle will be deflected. By means of a mirror attached to the needle, which will reflect the light from a lamp on to a scale behind, I can show you the deflection. I now form a very small spectrum, and cause different parts of the spectrum to fall on the junction of the metals. The needle deflects very slightly with the blue, showing that the heating effect is small; as it gets towards the green and

travels into the yellow the deflection is greater, and when we get into the red portion it is again more. At the very limit of the red the deflection is greater still, and outside this colour and in apparent darkness we see that the light on the scale travels further still, showing an increased heating effect. Thus an invisible part of the spectrum which lies beyond the red heats this junction of the two metals more than any part of the visible spectrum. We have here a proof that not only the rays which cause the sensation of light have a heating effect, but that we also have a heating effect due to dark rays which are not visible.

We have now had proof that light is capable of causing chemical action, and also that it is capable of heating a body on which it falls. If light acts only on the molecules it heats the body; if it swings the atoms further apart, the probability is that there is a chemical decomposition taking place. Those dark rays might possibly have had a chemical action on these pigments which were exposed in our tubes, but it was not probable. You see now the reason why we made experiments with light *plus* heat. I told you we exposed the pigments on paper against a vessel of boiling water to see whether the decomposition was accelerated. It was possible that these dark rays might have heated up the paper to such an extent that the heating action aided chemical decomposition by the blue rays which we found most effective.

FIG. 2.



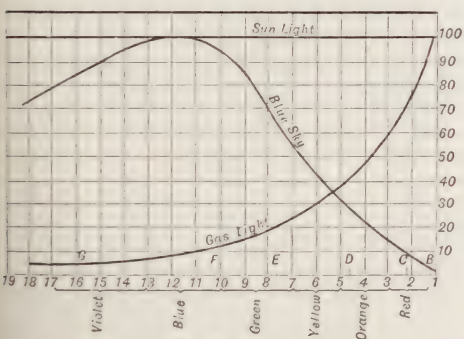
Now I want to call your attention for a minute to this diagram (Fig. 2), which represents the heating effect of different sources of light. The height of the curve is a measure of the heating effect. The curves on the right hand of the dotted line show the energy of the dark rays, whilst on the left the heating effect of the visible spectrum is shown. The heating effect (which is a measure of the energy) of the dark rays is very much greater than the heating effect of the rays which lie in the visible part of the spectrum. I want to call attention to the solar curve; you see what a peculiar jagged curve it has. The jagged indentations mean that some of the visible and dark rays of the sun, which lie in it, penetrating our atmosphere, are partially cut off by something, that something being water. These rays are absorbed by the water particles, and vapourise them. The vapour on being chilled again, condenses into clouds, and so we have a constant succession of aqueous vapour and clouds. I also want you to notice the enormous disproportion there is in the energy of the dark rays to visible rays in the incandescence light, as compared with sunlight. You see the incandescence light has very little heating effect in the visible spectrum, and a very large effect in the dark part of the spectrum. The same applies to gas-light and candle-light.

In estimating the chemical action of radiation on a body, there are two factors to be considered, the intensity of the radiation acting, and the time during which it acts. This is very important. Thus if a certain coloured surface be exposed to a radiation whose intensity we may call 100, which bleaches it in one hour, then if a similar coloured surface be exposed to intensity 1, it will require 100 hours' exposure to effect the same amount of bleaching. There is an idea abroad that if the light be very feeble, no matter what length of exposure be given, it will not affect a bleaching; this, however, is not the case. The same proportion of the total energy absorbed by the body which, with intense radiation, effects chemical decomposition, on exposure to feeble radiation is doing the same kind of work. We may say, briefly, that the deductions from scientific experiments lead us to believe that if strong light causes fading, a feeble light will do the same, if the exposure to it be prolonged. The pendulum experiment, I think, fully illustrates what I mean. I will give you a rather fuller illustration, however. The amount of increased swing that light can give to the atom means an increase in the amplitude of a wave, and the amplitude of a wave in the sea is the height from the crest to the trough. Suppose we have a heavy church bell hung without

friction on its supports, and without any resistance to its motion, and suppose it to make a complete swing once a second. Suppose also that at the end of the bell-rope there was a small horizontal plate, and at intervals of a second a thousand grains of water fell from a fixed height on the plate. The bell would gradually oscillate; the bell would be like this pendulum, and finally it would oscillate so greatly that the bell would ring. Now, if instead of 1,000 grains falling from the same height, we had but one grain falling every second, it would take 1,000 times longer before the bell rung; or if the weight were 1-1000th of a grain, it would take one million times as long before it rung. The work done by the dropping water may be looked upon as the work done by the amplitude of the wave of light on the atom, as it, too, moves without friction and without resistance.

As to the light which pigments in water-colour drawings are ordinarily exposed, a few remarks may be made. There is no doubt that pictures as a rule are carefully protected from direct sunlight, but it is nevertheless true that the greater portion of the light they receive is reflected sunlight. On a bright day the clouds reflect sunlight, and on a dull day the diffused light is also sunlight, which is reflected according to the laws of geometrical optics, and a large per-centage reaches the earth from the clouds. There is also a fair

FIG. 3.



proportion of light from the sky; this is bluer than that reflected or diffused from the weakened sunlight. In cases where the windows of a gallery are in vertical walls, which is the most ordinary case, and have an interrupted view of the horizon, the blue light reflected is comparatively small, the light near the horizon being distinctly more like sunlight than that nearer to the zenith. In galleries lighted like those at South Kensington the light comes from above. The artificial lights to which water-colours are exposed are gas-light, electric arc and incandescent lights. The first and last are very deficient in blue rays (see Fig. 3). You see, for instance, how deficient gas-light is in blue rays compared with sunlight or blue sky. Blue sky, you will notice, possesses hardly any red light whatever.

Now I think you will see why we were justified in exposing our pigments to sunlight instead of skylight. If you know the amount of blue rays that are in any particular light, and the amount of work such rays are capable of performing, it is quite fair to translate the action which one source of light has upon a pigment into the amount of effect from a different source of light. That is to say, if I know what action sunlight will have upon a pigment, then from diagrams such as the above, we can calculate the amount of action which skylight will have, and also the gas-light, whether the intensities of the total light are the same or different.

It is now necessary to explain to you how it was that we came to use three kinds of glasses for our experiments to see which part of the spectrum was most effective. As a preliminary, I should like to show you that a pigment may be very rapidly acted upon, although apparently perfectly inappreciably to the eye. I have here two transparent films which were treated with two dyes. Those two films were exposed behind a transparent cross to the electric light for ten seconds, and were then floated over with silver and a developer. From previous experiments we knew that where these particular dyes had been acted upon by light there silver would be deposited on them, and I think you will see that these two show that such is the case. The first film was dyed blue originally, and you will see where the light has acted the silver has deposited upon it. Here is another film, originally red, on which the same thing occurs. I want you to lay this thing to heart. Do not think that because an object does not visibly fade in a year that, therefore, it has not begun to fade at all. A year to one pigment may be the same as 30 seconds to another pigment, and if you expose pigments for a year, which will only fade as much as that particular pigment faded in 30 seconds, then, applying this silver salt, you will probably get exactly the same action after a year's exposure as you did with that shorter exposure on the more fugitive colour.

One more experiment. Here I have a piece

of paper which has been impregnated with silver salt, and has also been dyed with a colour. I want to show you that the smallest action of light on this particular colour will cause the reduction of silver salt. I am going to expose the paper to the spectrum for 10 seconds. [The paper here was developed.] You see in this case that we have a black band corresponding to the absorption spectrum of the dye with which it was dyed. This band is absent where the silver alone without the dye is acted upon. The dye has been acted upon, and thus caused a reduction of silver to take place where it has been altered, although such alteration is perfectly invisible to the eye.

Now I can show you why we chose red, blue, and green glasses for our experiments. I want you to notice the different parts of the spectrum that these particular glasses absorb. Passing the glasses through the spectrum, the red glass allows the red, and a little bit of yellow and green, to pass. With the green glass a great deal of the red is cut off, and all of the violet. With the blue glass you will see that a great deal of the red is cut off. Thus, in the case of the blue glass, we have the blue principally left, in the case of the green the green principally left, and in the case of the red glass we have the red principally left. Now, suppose I put the red glass and the blue glass together, what would happen? We only ought to have a bit of the red of the spectrum left, and if I put the green glass with these we ought to have nothing left, which is the case. In other words, the rays transmitted by those three glasses make up the whole spectrum, so that when using those we are utilising the rays of every part of the visible spectrum. It was for this reason we choose those particular glasses through which to expose our pigments. Fig. 5 shows the heating effect of the light after passing through the different glasses. Notice the dark rays. They are nearly entirely transmitted through the red glass, very slightly through the blue and green glasses. Had the fading of the colours we have examined been due to the dark rays, it ought to have been shown beneath the red glass far more than under the green or the blue glass. This was not the case, as a reference to Table IV. will show. We may, therefore say that the blue, violet, and ultra violet rays are those which are by far the most active in producing a change in the pigments with which we have experimented.

FIG. 4.

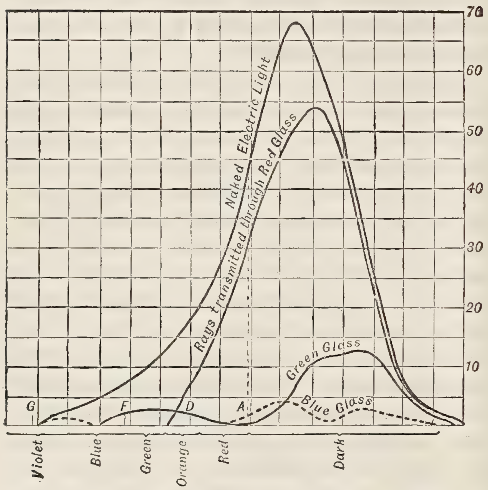
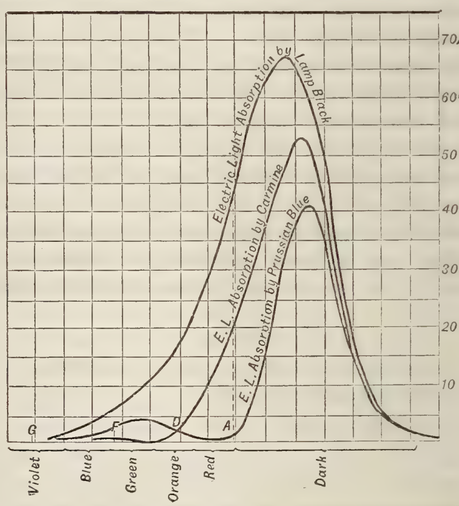


FIG. 5.



I may say a word or two about the exposures we gave, and the results deduced. We exposed between May, 1886, and the middle of August, and we found that during that time these pigments had 705 hours of bright sunshine. That bright sunshine we reduced to so much sky light, and the total amount of effective sky light received in that time was 1,700 hours. Allowing for overcast skies, and for blue sky light and sun light, we find that these pigments had an average of 2,225 hours of average of blue sky—or, roughly speaking, 2,500. We may now go a step further, and

calculate the amount of illumination which a picture shown in a gallery such as those at South Kensington would have during the same period. There is no direct sunlight, and making calculations from photometric observations, and seeing how much light came into the gallery, compared with that outside, we came to the conclusion that to have the effect on these pigments in the galleries which took place in the sunlight, we should have at least 32 years, supposing the light was always equally bright to that between May and August. But we know it is not equally bright, and we came to the conclusion that it would take 100 years to get the very little fading such as we got outside the laboratory in four months.

Now let us see what would happen to a pigment supposing it were exposed to gas light. Calculating the amount of blue light in such light, and also the total illumination in the gallery in question, we found it would require at least 2,000 years of continuous exposure for the same amount of effect to take place as occurred in the four months of sunlight exposure. After an exposure of one year and nine months, we have the astonishing result that to obtain fading of the same amount in the colours exposed, it would have taken 485 years of average daylight in the galleries to have got that amount of bleaching. If we had exposed it continuously to gas light, the time required is almost incredible to believe, viz., 9,600 years. With these facts before us I think you will say it is not at all surprising that we chose to use sunlight instead of any other source of light for our experiments. We wished to have whatever credit might attach to tracking out the cause of the fading. I am afraid that neither Dr. Russell nor myself are good for 480 years, and therefore we preferred to use the shorter time of one year and nine months in order to arrive at the conclusions we did.

The methods of measurement that I have brought before you are for the most part new, but I believe they can escape any very serious criticism. The details of many of the experiments, from which our calculations have been derived, have been published in various papers laid before the Royal Society and the Physical Society. I may say we have the greatest reliance on the accuracy of them.

I have now finished my course of lectures, and I have only to thank you for the great attention which you have paid to me.

SIXTH ORDINARY MEETING.

Wednesday, January 16th, 1889; Sir Frederick Bramwell, Bart., D.C.L., F.R.S., Deputy-Chairman of the Council, in the chair.

The following candidates were proposed for election as members of the Society:—

Barton, Thomas, 102, Jermyn-street, S.W.
Bignold, C. A. B., J.P., Norwich.
Britten, William Arthur, 299, Norwood-road, Herne-hill, S.E.
Curry, William Thomas, Chelvey, Backwell, Somerset.
Emerson, P. H., B.A., M.B., 10, Marlborough-crescent, Bedford-park, Chiswick.
Gleed, William, 9, Foyle-road, Westcombe-park, S.E.
Groves, Leonard, 10, Ampthill-square, N.W.
Hands, Alfred John, St. Ronan's, Fairholt road, Stoke Newington, N.
Ionides, Alexander A., 1, Holland-park, W.
Joerg, J. A., 16, Brunswick-square, W.C.
Kemp, John, 46, Cannon-street, E.C.
Mackay, John Charles, Stow Park, Newport, Monmouthshire.
Macpherson, Walter Charles Gordon, St. George's Club, Hanover-square, W., and Allahabad, India.
Morris, Evan, Roseneath, Wrexham.
Richardson, Arthur, Ph.D., 22, Meridian-place, Bristol.
Terry, John, Plate Grange, Boro Green, Sevenoaks, Kent.
Thacker, Samuel George, 22, Montague-street, Russell-square, W.C.
Wainwright, William, Carriage Department, South Eastern Railway, Ashford, Kent.
Wilkin, Colonel Walter H. (Alderman), 47, St. Mary Axe, E.C.
Worthington, Prof. Arthur Mason, 9, Tamar-terrace, Devonport.

The following candidates were balloted for and duly elected members of the Society:—

Boulnois, Henry Percy, Municipal Offices, Portsmouth.
Gillespie, Edward James, 16, Mincing-lane, E.C.
Grundy, James, 343, Derby-street, Bolton, Lancashire.
Hutt, C. F. Ormond, 28, Hungerford-road, Holloway, N.
Jeans, J. Stephen, Victoria-mansions, Victoria-street, S.W.
Middlehurst, John Edward, Springwood, Swinton-park, Lancashire.
Morley, John G., Heathlands, Chadwell-heath, Essex.
Pankhurst, Richard Marsden, LL.D., 10, St. James's-square, Manchester.

Tadman, Edwin Thomas, Cromer-lodge, West End-lane, N.W.

The paper read was—

THE CHANNEL TUNNEL.

By Colonel H. Montague Hozier.

When I request you to-night to bear with me for a short time, while I endeavour to discuss the question of direct railway communication between our country and the Continent, I must at once say that I do not propose, and I am not capable to advance, any arguments of an engineering or scientific character. I purpose merely to seek to examine this matter from a common-sense point of view. I wish to weigh those arguments which should guide ordinary opinion as to whether such communication would be advantageous or disadvantageous to us as a nation. On the mass of individual opinion public opinion is built, and it is public opinion which must eventually determine whether railway communication with the Continent shall be established, or whether we shall remain for ever, even more than in the days of Horace—

"Toto divisos orbe Britannos."

It appears to me that this question is essentially commercial and not military. If the commercial necessities of a country require such a communication, it must be the duty of the army and navy to provide for the security of our island, even under altered circumstances and new conditions. There was a certain increased risk of invasion incurred when steam navigation was introduced, and also when railways were established and developed, since both allowed troops to be concentrated and carried more rapidly than under previous conditions. Some military men objected strongly to the construction of railways; but the great Duke of Wellington swept away the objections, which had no influence on his clear and vigorous intellect; and during the fifty years that railways have endured no practical disadvantage has arisen from them. No one would now dream of proposing to prohibit by Act of Parliament that British subjects should own steamships, or that steamships should be forbidden to approach our shores, or that railways should not be allowed on account of the infinitesimal risk of danger which they still present. The commercial advantages of steam communication surpass so enormously the infinitely small risk it presents, that the risk is forgotten while the commercial advantages are daily more and more appreciated.

It seems to me that the question of railway communication between England and the Continent is much in the same condition as the question of internal railway communication was fifty years ago. There is an opposition—a strong opposition—to its establishment, and we must respect the opinions and views of those who still oppose it, but so soon as the enormous commercial advantages which must accrue to this country by its establishment are appreciated, the opposition will die away, and in a short time the fact that there was an opposition will be entirely forgotten.

Nor must we lose sight of the fact that our commercial prosperity is the first and most important element to be considered. Even from a strictly military point of view, it is our commercial energy and our commercial power which gives us the wealth that enables us to equip fleets and to recruit armies. Without the commerce which provides the most important of the sinews of war, we in England should be powerless as a military nation instead of holding a position in the forefront of the councils of the world. It is therefore most important to consider whether our commercial supremacy is threatened, and if so, by what means it can be most readily strengthened. I propose to discuss the matter in the following order:—

1. Whether for the sake of the maintenance of our commercial supremacy direct railway communication with the Continent is desirable.

2. If it be so, how that communication can be best obtained.

3. Whether any sufficient reasons of national importance exist to justify the Government of the country as guardian of the common weal in opposing the establishment of such communication.

The great Napoleon taunted the English with being a nation of shopkeepers. We now recognise that we are a nation of shopkeepers, and we glory in being so. It is on the fact that we have been the shopkeepers, the warehousemen, the carriers, and the manufacturers of the world, that our national wealth, and hence our national greatness, depends. To every interest in this island our commercial prosperity is of the most vital importance. This is self-evident as far as the manufacturer, and merchant, and all professions dependent or allied with the manufacturer and the merchant are concerned. A little consideration,

too, shows that the landowner, agriculturist, and every sort and condition of class, is equally involved in the matter of our commercial prosperity. Without the wealth which the merchant and the manufacturer collect and produce, the land and the produce of other classes would find reduced or doubtful markets. For many years after the beginning of this century England was commercially omnipotent, and had no rivals. Now the case is very different. The steam-engines formerly built in this country for continental markets are now made in Belgium or Germany; the construction of harbours, canals, and other engineering works are entrusted to continental firms. Manufactories of every description have been established, and are every day more extensively developed in every European country. On the other hand, although our commerce has not entirely stood still, yet it has increased far less proportionately than that of many continental countries.

Our commerce may be broadly divided into—

(*a*.) The products which we manufacture and export in our character as manufacturers.

(*b*.) The products which we import and distribute as warehousemen and distributors.

(*c*.) Our great carrying trade.

With regard to the direct exports of manufactures, although there has been no actual falling off in the values of the amounts which we have exported, yet our exports have not increased in anything like the proportion to our population, which the exports of most continental countries have to theirs. While our total exports increased in value between 1865 and 1875 about 27 per cent., those from Belgium increased about 95·83 per cent., and from Holland about 192·51 per cent.

Our distributing trade—that is, the products which we import and distribute—has very considerably diminished. From 1865 to 1886 the population increased over 23 per cent.; our total exports increased by 24 per cent., but the exports of produce brought here to be distributed only increased 10 per cent. An ingenious method has been discovered by Mr. Giffen of reducing values in different years to a common denominator. From this it seems that our foreign and colonial exports which, in 1873, were in value £56,000,000, fell, in 1883, to £23,000,000, a fall of £20,000,000 lost to this country. About twenty years ago the whole of the silk of Asia was brought to England in a raw state, and was thence distributed to the Continent. In 1875, the raw silk coming to England for exportation was 2,300,000 lbs.; in 1885, it had fallen to 300,000 lbs. This is a sample of a certain class of goods. Between 1865 and 1885 the imports from the Australian colonies into the United Kingdom increased 56 per cent., into France 11,000 per cent., into Belgium 5,400 per cent., and into Germany 6,600 per cent. Now it might reasonably be urged that the Suez Canal has been the cause of these changes, that goods from the East, which formerly came to England to be warehoused and distributed, are now sent through the Suez Canal on account of the facility of communication with continental ports on the Mediterranean direct to continental countries, and it cannot be denied that the Suez Canal may have done something to divert trade from this country. Telegraphic communication, which allows large stocks not to be retained, may also have done something, yet if the Suez Canal has been the cause of this diversion of the trade of England, it only shows that facility of communication with markets is of enormous advantage. Goods coming through that canal are not delivered at the place of manufacture, but have to go to ports where they are put on railways and sent to the factories by direct railway communication. But if we grant that the Suez Canal has done a great deal to divert trade in Oriental articles, such as silk, the Suez Canal cannot be responsible for the diversion of the distributing trade from America. In 1875, 2,300,000 cwts. of cotton came to this country from America, for export abroad; in 1885, the amount of cotton brought from America to the United Kingdom for foreign exportation had fallen to 1,800,000 cwt. The diversion of the United States trade cannot be due to the Suez Canal. A great deal of this trade goes to the northern ports of France, or in the case of Belgium, Holland, and Germany, to the North Sea ports. Formerly these ports traded only with England; bulk was broken at English ports, and goods were trans-shipped in small vessels. Now bulk is not broken, the large steamers run direct to the continental ports, and the trade which used to give employment to our merchants, our warehousemen, lightermen, docks, dock labourers, and stevedores, passes by our shores and goes straight to our foreign competitors.

I do not wish to weary you with dry arrays of figures, but this fact may be clearly seen by the following considerations:—

The value of goods imported from the United States into the United Kingdom increased in

the 15 years following 1870 by about 60 per cent., while that of the goods imported into Belgium from the United States increased 280 per cent., and into Holland 161 per cent. Coffee, too, exported from the United Kingdom to continental countries, for which the Suez Canal cannot be to blame, in 1875 was 1,170,000 cwt., but in the year 1885 fell to 700,000 cwt. On the other hand, certain imports into continental ports have increased very largely. The wool imported into Antwerp, in 1865, was 115,558 bales; in 1885, was 200,618 bales. From the River Plate, which cannot be affected by the Suez Canal, the import of wool into Dunkirk, in 1865, was *nil*, but in 1885 it was 138,866. The coffee imported into London, in 1875, was 79,700 tons, in 1885 it had fallen to 51,780 tons. The import of coffee into Havre, which, in 1875, was 45,650 tons, had risen, in 1885, to 100,890 tons. Thus, while the import of coffee into London fell by about 28,000 tons, that into Havre increased by about 55,000 tons. These figures, and many others, prove conclusively that articles of this nature have been diverted by being sent direct to continental ports, where they can be put on railways and sent directly to the place of manufacture. The manufacturers of England are allowing the raw material to be sent to their rivals chiefly, as it seems to me, because they will not give their customers easy access to their markets, and obtain facilities for the prompt delivery of their goods. The great manufactures of the world are surely and not slowly being transferred from England to settle in Belgium, France, and other countries, and our financial business is following them. The course of finance is undoubtedly following the course of trade. It is indisputable that an enormous amount of financial business that used to be done in London and England is now being transferred to Antwerp, Havre, and other places, because goods are consigned direct to these parts. Those who study the correct records of late commercial history must feel that we are daily committing one of the greatest errors that a nation of shopkeepers can commit in maintaining a difficult access to our factories and warehouses on the part of our customers. Few can study without surprise the returns of the travellers who pass from Italy to France, from Spain to France, from France to Germany, and from Russia to Germany, and the comparatively small number of passages made between the Continent and England. It is only natural that continental customers should prefer to make their purchases on the continent of Europe rather than cross the Channel and come to England. What would any sane man think of a large shopkeeper in this country who provided every facility for his customers, spacious and clear entrances to his stores, well covered porticos, easy access to his counters and prompt delivery of his goods. It would immediately be remarked that that man was entering on a course which would probably lead him to wealth. What would the same critic think of another shopkeeper who said to his customers, "I will supply you with the best goods at the cheapest rates, but I insist as a preliminary to your entering my shop that you should be tossed about for two hours in a diabolical machine. Your ears will be offended with the creaking of machinery, your nose with the smell of oil, and a number of people around you will be visibly and painfully ill." Would it not be believed that this shopkeeper was taking the most happy measures to reduce himself to bankruptcy? Common-sense dictates that facilities of communication between purchasers and markets must be of enormous commercial importance. Yet our manufacturers and our merchants insist upon their continental customers undergoing an ordeal from which it is not unnatural that the continental customers are only too ready to recoil. Within our island we appreciate facility of communication, and neglect no opportunity of increasing it. Bridges are being thrown across the Forth and the Tay to connect the small population north of those estuaries with their fellow-countrymen in the south. Tunnels have been driven under the Mersey and the Severn; Manchester is constructing a ship canal. Everywhere railways are developed except to connect England with the Continent, and to open our markets to the most numerous of our customers. In other countries the same is seen. Great bridges have been thrown over the Mississippi and the Ohio. Tunnels have been driven through the Alps under Mont Cenis and the St. Gothard. The Alps were almost as formidable a strategical obstacle between Italy and France as is the English Channel between England and France, but the Italians had no fear in allowing tunnels to be constructed.

With regard to our carrying trade, I shall only quote a few figures. The tonnage of vessels passing through the Suez Canal from the East to the various countries of Europe, have increased between 1875 and 1885 as follows:—

United Kingdom	361·59
France	505·63
Germany	1,412·88
Italy	338·31
Austria	367·44
Holland	360·02
Belgium	5,686·40
Russia	483·75
Spain (home only)	640·56

The increased proportion of passages, in most cases to foreign countries, I attribute to the fact that the ports of these countries are in direct railway communication with the markets for which the goods are intended.

In England we have much more reason to encourage facility of communication than have the French or Italians, who have tunnelled the Alps. We were the manufacturers of the world, the great distributors of the world, the great warehousemen of the world, and the great carriers of the world. Our country was the landing-stage of the passenger traffic between America on one side and the continent of Europe on the other, between South Africa on one side and the continent of Europe on the other, and for the great trade which comes from Australasia and the East. Yet our carrying trade is going away from us. This is not entirely due to the want of railway communication between England and the Continent, because it undoubtedly is due partly to the enormous facilities for navigation offered at continental ports such as Dunkirk, Antwerp, and Hamburg, while very little or nothing has been done to improve the accommodation for shipping at British ports. Yet had there been facilities for foreigners to come to our warehouses, and to obtain their goods in England, it is doubtful whether these continental ports would have made the improvements which they have made. They would not have been able to offer the temptations to shippers which they now offer. The reason that our carrying trade is so much diverted is because when goods are brought to this country they cannot be put on railways and sent to their places of consumption. They have to be unshipped here, put on railways, taken to the coast, handled, broken, put into the boats, transported across the Channel, to be put on another railway, and then forwarded to their destination. I do not in the least maintain that all goods could be forwarded by direct railway communication to the Continent. Heavy goods certainly could not be so forwarded, but in many instances of light and perishable goods they could be sent across. If we had direct railway communication with Lyons, for instance, there is no reason why silk from London should not be forwarded quite as safely and as quickly as it is now from Marseilles. Coffee consumed in Germany or Poland is now delivered at Havre. It is quite as difficult to convey coffee from Havre to Warsaw, as it would be from London, provided we had unbroken railway communication.

In passing, I may notice that certain shipowners are afraid that unbroken railway communication with the Continent would lead to a diminution of their business. When railways were about to be established between Scotland and Ireland the owners of the coasting vessels opposed the establishment of such railway communication on account of the fear that railway communication would ruin the coasting trade. Their fears were groundless, for the coasting trade which in 1853, about the time of the establishment of railways, was only a little over 31,000,000 tons, in 1887 had risen to nearly 84,500,000 tons. It is almost certain that the great impetus which uninterrupted railway communication with continental countries would afford would create nearly as great an activity in every trade as was given to every branch of commerce by the introduction of internal railways.

If it be granted that for the sake of the maintenance, and possibly in order to regain some of our manufacturing trade and distributing trade, railway communication with the Continent is desirable, the question arises how it can best be obtained.

The most obvious mode to carry a railway across a piece of water is by a bridge. To a bridge, too, of course there could be no military objection, since it is readily recognised that a bridge could be destroyed at any moment in case of an attempt being made to pass an invading army across it. On account, however, of the necessities of navigation, and for other reasons, it is very doubtful if, at the present time, a bridge across the Channel could be constructed, except at a prohibitive cost, although I believe that active proposals are being made for such construction. Thus a bridge is, at present, practically out of the question. If, however, we cannot go over the water, we may, in this case, easily go under it. Here, everything seems to favour the enterprise; the rock through which a tunnel must be driven is most favourable. The strata are peculiarly adapted to suit the necessary gradients. Nature in every way seems to proffer a helping hand to establish rail-

way communication with the Continent; yet we ungratefully cast aside her aid, and spurn the ready opportunity, although the commercial advantages of the establishment of such communication are incontestable. The only arguments which can be advanced against availing ourselves of the advantages which nature offers are based upon the idea that, in some way or another, the construction of a tunnel might facilitate invasion. These arguments have been advanced by great and illustrious men, whose opinions are entitled to every respect and every consideration. Yet it appears to me that the military authorities have been placed in a false position with regard to this matter. The question is a commercial question ; not a military question. On all such matters the military advisers of the Crown, if the Government throws the responsibility of the decision upon them, must, if there is the slightest risk of danger, oppose any new departure. Had the question of permitting submarine telegraphic communication between England and France been submitted to a military commission, a military commission would undoubtedly have reported against it, for some of the arguments would apply to a submarine cable as to a submarine tunnel. The English end of a submarine cable in case of invasion might be seized by the enemy, and by his obtaining telegraphic communication with his own country he would be placed in the most favourable position to order up reserves of troops, stores, and ammunition, but nobody dreamt of submitting a commercial question, such as international telegraphic communication, to a military commission. The Government decided that question on its own responsibility, and are quite content to leave it to their military advisers, in case of need, to take precautions for the safety or destruction of telegraphic communication with the Continent. The Government should determine on commercial grounds, as in the case of steam navigation and internal railways, whether a certain undertaking would be nationally advantageous, and if it be nationally advantageous then the military experts should be called upon to provide means for securing the country from any possible danger which might accrue from it. As every steamer which is built in any continental port must afford some infinitesimal risk of invasion to an island—as every railway which is constructed within our own shores must also afford some infinitesimal risk of aiding an invader in case he should be able to seize it, so the construction of a tunnel, if every possible combination of fortuitous circumstances favoured our enemy, might give some infinitesimal risk of advantage to the invader. But the risk afforded by the tunnel is, to my mind, much less than that afforded by either steam navigation or by internal railway.

The arguments which have been advanced against the tunnel in a military sense may be divided broadly under three heads.

There is the argument that an enemy might invade our country by marching directly through the tunnel. Secondly, there is the argument that an enemy might concentrate an enormous quantity of troops in some internal portion of his territory, pour them into railway trains, and push these trains one after another through the tunnel. These troops, arriving rapidly, would debouch from the tunnel, form line of battle, sweep away any defending force, and march straight upon London. There is a third argument that an enemy might send a small force across the Channel, seize the outlet of the tunnel, hold it in spite of our efforts to retake it, and then at his ease pass his army under the seas upon which our fleet might be riding victorious, but yet be unable to impede its progress.

Let us now examine these arguments—not in any spirit of over-confidence, but calmly and dispassionately. We must remember what is sometimes apparently forgotten—that the tunnel as proposed is to be a tunnel between England and France. The foreign outlet of the tunnel will be on French soil, therefore no other nation except the French can, unless it either first conquers France or is allied with France, avail itself of the tunnel for the purpose of invading our island. It seems hardly conceivable that France is likely for many years to come to ally itself with any of its neighbours for an invasion of England ; nor does it appear, as far as political foresight goes, that France alone is likely for many years to come to engage in a contest with our country. However that may be, the one fact remains that it is against the French, and the French alone, that we have to guard as possible invaders of England.

We will say nothing of the alliances which England might form abroad, and which might bring enormous forces to bear against the flank and rear of a French army moving upon the French mouth of the tunnel. We will not consider that the eyes of military France have been for many years past, and will in all human probability be for many years to come, cast on

a very different portion of her frontier than the British Channel. We will for argument's sake consider that the French are anxious and eager to go to war with England, and to throw England's weight and England's naval supremacy into the scale against them. And then we will endeavour to examine what chance of success a French invader, even under the most favourable circumstances, would have if he adopted the Channel Tunnel in any way as his means of attack.

Let us for a moment imagine ourselves in the position of a French Minister of War about to undertake an invasion of England through the tunnel. Troops must be concentrated. It would hardly be safe to attempt such an enterprise with a less force than at least 30,000 men. These would have to be brought together at the Calais end of the tunnel. They must be mobilised, put on a war footing and equipped for the field. Such a concentration could hardly be unknown within a few hours in England. Rolling stock would have to be collected for their conveyance, and certainly at the very least three days must elapse before the troops would be in a condition to move from Calais. The tunnel would be thirty miles long. It would be impossible to march into the tunnel unless the traffic from the English side was stopped. Otherwise the marching column would very quickly be encountered by a train going at full speed up the tunnel, and would be cut to pieces. The suspension of traffic from the French side to England would immediately be known, and cause inquiries and doubts. If a small party were sent forward from the French side to take up the rails somewhere in the tunnel, in order to stop the English traffic, the first train from the English side which came down would be wrecked, and the tunnel would be *ipso facto* blocked. Even in these details there would be an enormous risk of failure to the invader.

On good roads and in daylight troops cannot make more than 2½ miles per hour. Troops marching through the tunnel in the dark, over ballast and sleepers, encumbered with their ammunition carts, with their artillery and with their cavalry, would not be able to march at anything like the same rate. But if we assume that they could make 2½ miles per hour, then the leading sections could not reach the English shore under 12 hours' continuous marching. In those 12 hours there would be abundance of time to ascertain that all the defensive measures which have been laid down as necessary for the defence of the tunnel were in fair working order, and by the time the head of the invading columns was but a very short distance advanced the tunnel would be flooded.

It is also very frequently forgotten that the tunnel on emerging from the sea would not impinge on the surface of the ground, but where it comes from under the sea it must be sunk to a depth of at least 100 feet. From this point either the carriages must be run through a land tunnel a mile and a half long to secure the necessary gradient to reach the surface, or be raised by hydraulic lifts or some mechanical contrivance. The land tunnel could have every means of being mined by galleries which could be inspected at any moment, charged in a few minutes, and the tunnel wrecked on the shortest notice. If the carriages are brought to the surface by hydraulic lifts, certainly ample means could be taken in a few minutes for rendering these unserviceable and impracticable. When we consider that in the war between Germany and France the German troops would not use for their advance the tunnels through the Vosges, which had none of the dangers of being flooded or of being specially prepared for defence, it seems to me ludicrous to imagine that any sane Minister of War would ever attempt to invade this country by ordering troops to march directly through a channel exposed to every danger which could almost be imagined.

The Germans, who have had great experience in war, consider that it would be suicidal to send troops along any railway without bridges or without tunnels, unless they had already secured the further end of the railway and held the whole line in possession and in the power of their patrols. To endeavour to march through the tunnel with an army and invade the country would be sheer madness. Troops would not even, if they did reach the English end, be able to deploy and take up any wide front. As Lord Wolseley has said, 50 of our riflemen could in such a case stop the whole invasion.

Secondly, it is argued that troops might be collected within France itself, and suddenly poured through the tunnel in railway trains so as to invade England. These troops would require to be concentrated, and certainly they could not be so concentrated and mobilised under three days, even if the French Government were rash enough to undertake the enterprise with such a small force as 30,000 men. It has been proved by the most per-

fect practical experience in war that troops equipped for fighting cannot be moved along a double line of rail at a greater rate than 10,000 men per day. It must be remembered that troops going into battle are not like ordinary passengers; they are not even men with muskets and knapsacks. They must carry with them their supplies of ammunition, their artillery, their cavalry officers' horses, baggage animals, and a great deal of other impedimenta.

Trains to carry soldiers thus equipped cannot be loaded very quickly, and it must be remembered that one single rail being lifted would wreck the first train, and prevent any of the others passing. It is impossible that information should not have reached England in time to allow a few rails to be removed before the first train arrived, and the *débris* of that train would prevent the passage of any others. Even if one train did come through before the alarm were given, if such an apparent impossibility occurred, its arrival would give the alarm; the tunnel would be flooded, the soldiers in trains which had already entered would be drowned, while the men in the train already arrived would fall easy victims. To collect troops in the centre of France, and to shoot them through the tunnel as suggested, as if the tunnel were a pneumatic tube, would be absurd. One pointsman, or one telegraphist taking up a rail would destroy the whole expedition.

It appears to me most impracticable to argue that armies can be shot through a tunnel as a pea is shot by a boy through a pea-shooter. One of the most elementary maxims of war is that an army should not be committed to even a short defile unless the further end is firmly secured by advance guard. I am sure Sir Myles Fenton, or any of our great railway managers, could assure us that even under ordinary circumstances, and under very favourable conditions, to bring a number of ordinary passengers along a narrow line of rail requires considerable forethought, organisation, and method. Any layman even can see that there must be a great machinery required in the way of signalmen, pointsmen, station masters, and other staff. To fill trains with troops in the interior of France, and shoot them through to Dover without having secured the Dover end of the tunnel, appears to me an act that no sane Minister would ever undertake.

There is a third argument that a small force might be sent across in vessels, land in this country, seize Dover, where the mouth of the tunnel is proposed to be, and would seize the shore end of the tunnel, and so gain it for the passage of the invading army. If troops, however, were sent across in boats, in small quantities, they would certainly be discovered before landing, and would be such a mere handful that they could not possibly seize the end of the tunnel against the garrison of a first-class fortress at Dover. If, on the other hand, they were to come in a large quantity, then it seems that at the present time we are open to invasion across the sea. It must be remembered that to collect sea transport for troops, to concentrate troops, to place them in vessels with all their equipment, horses, and ammunition, is a work of considerable time. To bring them across is a work of some difficulty, and disembarking troops especially in the presence of the enemy is a matter of difficulty and also of time. When the British army invaded the Crimea and had to disembark them without any opposition, it was impossible on the first day to get more than 2,000 men ashore. Is it to be believed that suddenly a sufficient force of troops could be sent across the Channel to seize Dover without any alarm being given, without any precautions being taken, and without a single vessel of the British Navy being in the Channel to dispute the passage? We must remember that there are Englishmen, official diplomatists, official agents, private firms, *employés* of railway companies, and many other classes scattered in enormous numbers through France, it would not be possible for the French to concentrate and move troops upon Calais without information being received in this country. The English press has its eyes everywhere, and is probably of greater assistance as a military intelligence department to our country than has ever yet been thoroughly appreciated. The Press would report any collection of troops in France.

If a French army could land and seize Dover, an invasion is possible without a tunnel at all, but the idea of Dover being captured by a French army collected without our knowledge, and transported across the ocean without our knowledge, while our navy is still unimpaired, is perfectly chimerical. The truth about invasion is that so long as the British Navy can sweep the seas, an invasion of this country is impossible, and it does not in the least matter whether the Channel Tunnel exists, or otherwise. If our navy is not strong enough to hold the seas, it would require no

invasion to reduce us to any terms the enemy might choose to impose. There is often, in this country. not more than six weeks consumption of food for our teeming population. If our navy could not hold the seas, our supplies of food would be cut off, and we should be obliged to surrender as surely and certainly as any blockaded city is, when provisions are exhausted, and hunger forces it to capitulate. The key to the security of England lies in the maintenance of an efficient and overpowering navy. If we have such, we can laugh at the panic of those who see any cause for fear in the construction of a tunnel.

It has been argued that if the tunnel existed, and we were defeated or invaded by another route, one of the conditions of peace wrung from us would be that we should hand over the tunnel to our enemy to use as they liked. If there were no tunnel, and we were so heavily defeated or invaded by another route, might not, even at the present moment, the demand be equally made that we should give up our navy, and if we were compelled to do so, then our shores would be opened freely to the invader, without the question of whether there was a tunnel or not.

It has been stated that, in the course of time, if the tunnel existed, our sentries would become negligent, and precautions would be allowed to fall away, and we should be, through more security, liable to be surprised. It is difficult to realise, even if that were the case, how the tunnel could be seized, as the troops to march through and seize it would require 12 hours, and the stoppage of all traffic, and consequent alarm. The troops coming across the sea would require transports to assemble, and considerable time would be required for disembarkation. But there appears to be no reason to believe that our sentries are liable to be negligent. Malta and Gibraltar are not supposed to be negligently guarded, and have not for many years been open to attack. The sentries there have not gone to sleep, nor have the officers been found wanting. If soldiers are not to be trusted to guard the fortresses committed to their charge, there is little use in going to the expense of fortifying coaling stations, or building defensive works anywhere. Certainly if the troops who are to hold them are so unworthy of confidence that they cannot be expected to preserve our national interests and our national honour, the least we should do as men of business is to save our national pocket.

Although, as far as I can see, no military disadvantages could accrue from the construction of a Channel Tunnel, it is conceivable that from its existence some valuable military advantages might arise.

If we were at war with another country than France, the tunnel might afford us means of communication which would be very valuable. It is to be sincerely hoped that we may never be at war with the United States, but if such an unhappy catastrophe occurred, the United States would certainly cover the seas with cruisers and men-of-war, and we should probably be more hardly pressed to hold our maritime supremacy than in the case of war with any other nation. If American frigates, even for a temporary period, prevented our food ships running across the seas, we should be exposed to severe distress and danger of famine. In this case, however, if a tunnel existed which could not be assailed by hostile cruisers, we might draw our supplies through France, and thus feed the country, which would otherwise be compelled to capitulate through hunger.

In conclusion, I would wish briefly to summarise my arguments, which I have endeavoured to express as follows :—

1. That our position and prospects as a nation depend in the main upon our commercial prosperity.

2. That that commercial prosperity is being jeopardised by the want of railway communication between this country and our customers and markets on the Continent.

3. That this railway communication can only be obtained economically, and certainly by a Channel Tunnel.

4. That the national dangers to be apprehended from the construction of this tunnel are so infinitesimally small that they cannot be weighed against the commercial advantages likely to arise from that construction.

I have not touched upon the position in which we now stand with regard to foreigners, but it is not pleasant for Englishmen travelling abroad to find how friends of our country lament, and enemies of England scoff at the position taken up by our Government with regard to this matter. It is galling to be assured that the military valour of England has departed, and that the army which carried the British colours early in this century from Madrid to Toulouse, from Brussels to Paris, is now incompetent and afraid to defend the narrow issue from which hardly twenty men could advance abreast. We can only trust that if those who believe in the

advantage of this scheme temperately and quietly place their views before their fellow countrymen, reason may before long again in England assert her sway, panic and prejudice may be put aside, and that both our allies and our enemies abroad may again recognise that the glorious heritage bequeathed to our country by Nelson and by Wellington has not fallen into unworthy hands.

Finally, I must add that if I have not been able to communicate to you a conviction that a Channel Tunnel will be not hurtful but beneficial to us as a nation, my failure is due to no want of strength in the case, but to want of skill in the advocate.

DISCUSSION.

The CHAIRMAN, in inviting discussion, remarked that this paper was well worthy of the reputation of Colonel Hozier. It dealt especially with two aspects of the question, one, the advantages which would arise from railway communication with the Continent; and the other the dangers, if any, which might be feared. He hoped speakers would address their remarks to these points, and avoid the sentimental aspects of the question.

Admiral COLOMB said he did not know that he could add anything to what had been so well said. He thought, however, that when Colonel Hozier said there were only 2,000 men landed in the Crimea on the first day, he had fallen into a clerical error, and that the real figure was 20,000, but that did not, in his opinion, weaken the force of the argument. According to his recollection, those troops were landed, without baggage, with only two days' provisions, with hardly any artillery or cavalry, and with a very short supply of water. They remained on the beach for 24 or 36 hours before the rest of the army could be landed, in consequence of the surf. He had been much struck by the fact that there would be $1\frac{1}{2}$ miles of tunnel on shore, which could be easily defended, and under those circumstances he did not see how a surprise was possible. As to the general scope of the argument, he had always felt that the commercial advantages would be so great as to outweigh any possible risk, even if it were mnch greater than appeared to be the case. He did not think there was the slightest possibility of invasion, even if the navy were allowed to run down, which he did not think was likely. Steam and telegraphs had made defence much more easy than it ever was in the days of sailing vessels, and he thought the idea of a force crossing the sea and effecting a landing, whether large or small, might be thrown completely aside.

Admiral Sir Erasmus OMMANNEY, C.B., F.R.S., also agreed that the idea of an invasion was nothing more than a bugbear which might be disregarded, especially in view of the means we now possessed for rapidly concentrating troops. He agreed with the paper entirely.

Mr. GRIFFITHS, as the author of the only book published on this subject, "Under the Deep Sea, or the Story of the Channel Tunnel," could not refrain from expressing his thanks to Colonel Hozier for so thoroughly exposing the invasion bugbear. If we had a navy at all, and he thought we had, manned by men as competent as their predecessors, to deal with the enemies of England, we could surely rely upon it to protect us against the danger of a few Frenchmen getting into boats at Boulogne or Calais and crossing over. Our intelligence department was as good as that of any foreign nation, and our navy would protect us against any surprise. The Government, before opposing any Bill of this kind ought to state its reasons, which never had been done yet, and then it would be quite time for Colonel Hozier to answer them.

Mr. OLIVER J. WILLIAMS said no reference had been made to the cost of construction, the compensation to be paid if the tunnel had to be destroyed, or the cost of the fortifications at the mouth of the tunnel. It was a question if the money might not be more advantageously used in the construction of vessels which would convey railway carriages and trucks, which might be transported bodily to the French harbours, and whether commercially such a method would not be more profitable to those who found the capital. Again, he thought one of the great dangers was not a sudden invasion, but the difficuly of maintaining the communication. If there was a comparatively slight block put in the way the enemy might be able to clear it away, after having seized the English mouth. France had only been spoken of, but France might have allies, and probably it was not the French nation itself we need fear so much as other nations attacking India on one side, whilst France might attack us on the other. Then referring to the commercial side of the question, might there not be a much greater disadvantage in the direct importation of so much foreign goods, which would oust English goods from the market? There were already complaints of the cheap rates to the Continent leading to a great influx of continental produce, and with through trains this might be further developed, and make England poorer rather than richer. All the working-classes were complaining of the cheap labour which came from abroad, and this would be increased by the direct communication. The horror of sea-sickness was nothing to commercial men, or if it were they would think equally of the foul atmosphere of a long tunnel. If a railway could do everything why should the Manchester Ship Canal be projected? Water freight was very much cheaper than land carriage, as was shown by the increase in

the coasting trade, in spite of the extension of railways.

Mr. P. G. Craven thought it was utterly impossible for the tunnel to be a commercial success. The direct freights from continental ports to England during the last five years had been something like 5s. a ton, and he did not believe that any of the southern railways had a 5s. tariff from the coast into London on their list. The freight through the tunnel could not be more than 5s. a ton, if it was to compete with water carriage. Where was the enormous capital required to be raised? The communication with the Continent had increased enormously; at Folkestone there were three or four little steamers trading every day, and bringing over goods. Then they would have to come into competition with the direct steamers from Boulogne or Rotterdam to London. Colonel Hozier had alluded very forcibly to the falling off of the trade of England, but that was owing to the fact that there were now splendid docks, equal to any of our own, at Antwerp, Dunkerque, Havre, and elsewhere, and behind those was the whole of Europe. England was only an island, and therefore, the goods which used to come here to be transshipped, now went direct. St. Petersburg was now supplied direct from America, although the whole of the cotton used to be bought in Liverpool, and sent across by rail to Hull or London. The coffee, also, for the Continent now went to Hamburg or Havre. An association had been formed to try and bring back some of that trade to England, but he did not think it would have much effect. Our own liners called at Hamburg and Havre, to fill up. All this cheap transit had inundated England with goods from the Continent, and he could not see that the tunnel would help the trade of England in any shape or form.

Mr. W. Smartt said a charge of 5s. on a transit of 30 miles was equal to 2d. a mile, but it paid railways in this country to carry goods three miles for 1d. per ton, so that there was ample margin to allow for very good profits even on goods alone. But with such an enormous population as that of England and France, he thought the passenger traffic would be quite sufficient to make the tunnel pay, especially considering that there was no land to pay for, except at the entrance at each end. As to there being any increased danger of invasion, he thought it was exactly the reverse. The greater intercommunication there was between nations, the greater was the prospect of peace. If the tunnel were made, Germany would be less disposed to fight France, because there would always be the chance of England joining the latter country, and sending an army to her aid. It would be very easy to render the tunnel perfectly safe. Electric wires might be laid in connection with the land portion of the tunnel, by which, in case of danger, the authorities, even at a distance, might explode the tunnel and render it useless.

Captain E. O'Callaghan said he could not go into statistics, nor did he think it was much use to do so, for he found that when any man had a theory to advocate, he could always find figures to support it. The only point he would touch upon was the military one, and he had noticed that several objections which he considered absolutely fatal to this scheme had been placed before the public, some by H.R.H. the Commander-in-Chief, and some by Lord Wolseley, that those objections had not even been stated, much less controverted. A memorial against the Channel Tunnel was got up some time ago by the editor of the *Nineteenth Century*, and it was more influentially signed than anything of the kind which had ever been put forward in this country.

Surgeon-Major Ince said that the gallant Colonel had treated the objections just as one might have expected from an engineer officer, for he had simply exploded them. As a military man he would warn the public against relying too much on technical opinion of any kind, especially in matters relating to any branch of the public service, whether military or naval, because our military and naval men were so much afraid of going wrong, that they were almost certain to follow a leader without exercising their own judgment. The objection to the tunnel could not be said to be either physical, commercial, or national. What did the French say to it? Had they got up public meetings and called on the Government to raise objections to opening a door on their side of the channel? They were told that men with great names had given the weight of their opinion against the tunnel, and this could not be denied. He thanked the gallant admirals for what they had said, but they were, most of all, indebted to Colonel Hozier for the lucid, earnest, and instructive manner in which he had dealt with frivolous objections.

The Chairman said Colonel Hozier had not alluded to the fact, of which he was doubtless aware, that the disfavour with which the tunnel had been lately viewed by successive Governments was entirely a new thing. In 1871, the English Government informed the French that they saw no objection in principle to the proposed tunnel between England and France; in July, 1873, Lord Granville wrote to Lord Lyons that the Board of Trade would gladly see any improvement in the communication between this country and the Continent, and they would therefore be well satisfied to hear that the British railway system was likely to be connected with the European railway system by means of a tunnel between France and England. In 1874, Lord Derby wrote to Count Jarnac to the same effect, provided no Government loan or guarantee was asked for;

and in 1875 the Royal assent was given to a Bill authorising the preliminary works. It was under such encouragement that not only a body of gentlemen in England advanced the sum necessary for the preparatory works on this side, but that a body of gentlemen in France expended a large sum, as much as £80,000, in the initiation and trial works, and all that money was at present utterly thrown away, although these expenses had been incurred on the faith of these distinct statements on the part of the Government, ranging from 1871 to 1875. That seemed to him a very unfortunate state of affairs, not only as regarded the consistency of our own policy, but also as to our mode of keeeping faith with our neighbours. As to the concern being a paying one, that was the business of those who chose to embark their money in it. We had nothing to do with grandmotherly legislation, taking care of the widow and orphan, and that sort of thing, people with money must take care of themselves. When that doctrine prevailed, England became a great country, but now-a-days people were taken a great deal too much care of; in his view, the only proper business of the Government in this matter was to see that nothing was done which could be a national danger. Under these circumstances he would not go into the question of what the tunnel would cost, especially as Colonel Hozier had not done so, beyond saying this, that if the work could be done at all, of which he had no doubt, it would be the engineering equivalent of what was called a military promenade. It was to be done in a particular stratification which there was the best reason to believe existed at the very point where it was wanted, and that it was continuous throughout. In that formation the work was literally to mechanically perforate in a stone so soft that it could be cut by a common table-knife, yet so solid as to remain intact without supports for days, and as they knew by the trial heading, for four or five years without the slightest depreciation. The excavation, therefore, became one of absolute simplicity, it would need no support by timbers; and the lining could be done at leisure. He was, therefore, entitled to say that if the work could be executed at all it could be done cheaply. Of course if they came across some great fissure, or a great barrier of trap rock a mile in thickness, it might be brought to a dead stop, but he did not believe there was any such obstacle to be met with. They knew the formation on each side, and if it reached all across—as there was every reason to believe was the case—it would enable the work to be carried out most cheaply. The question had been put as to compensation in the event of the tunnel having to be flooded under the stress of an invasion. As to that, he would point out that the tunnel would be some 150 feet below the sea, a little higher in the middle than at the two ends, so as to give a slight decline for any leakage to come down to the two ends, and then it would rise again, thus leaving a valley near the shore at each end. Sluices might be made of any size, these could be worked hydraulically from the middle of Dover Castle, and by means of these sluices the sea, under a pressure of 150 or 200 feet, could be turned into the tunnel. The whole of the tunnel need not be filled up, only about one mile would suffice, and then seal the valley end of which he had spoken, and it would be absolutely secure against any invasion, except by a fish. It might be said if the enemy landed, the first thing he would do would be to pump it out. But the sluices might be any size you pleased, and they might be so worked that no human being could get at them to move them unless he obtained access to the controlling machinery, say in Dover Castle, such machinery being left uninjured for the enemy's use. The pipes might be laid to any fortification—to Dover, or elsewhere, and from there the sluices might be worked, but from nowhere else. In such circumstances, what would be the use of all the fire-engines in Dover, even with the aid of those from Canterbury, to pump out the tunnel? Then, with regard to compensation for such a flooding. In the first place, no doubt the promoters would be willing to take a bill, and forego any claim to compensation, and it might be deemed right to impose that condition, but what would the damage amount to? When the sluices were shut, the erection of machinery to pump it out would be a matter which any coal-mining engineer would deal with in a moment. You could never get the water out till the sluices were shut, but when that was done it would be a matter of comparatively small cost, and the injury would be practically *nil*—only a little sea-water in the tunnel for a certain time. Then again, with regard to the 150 feet depth, to rise from the level of the tunnel to that of the surface, would involve, if an incline were used, a land tunnel of, say, $1\frac{1}{2}$ miles, and that portion would be on English soil, and you could do what you liked with it. But he believed the cheapest mode of construction would be to make a vertical hydraulic lift. There were now in use in England and in France hydraulic lifts to raise vessels of considerable size from a low level canal to a higher one. A train of passengers weighing 300 tons was not worth talking about for a hydraulic lift; a single 15-inch ram would lift it, but you would probably use several rams. Fancy the condition of any madman who intended to invade the country by means of a railway which came to a termination at the bottom of a shaft 150 feet deep, up which he could only get by means of a hydraulic apparatus, the pipes in connection with which were in some secure place properly guarded. The lift might be always kept at the top, and then it could not be got down, or it might be at the bottom, and then they could not get it up. What would be the condition of 1,000 men at the bottom of a shaft 150 feet deep, with vertical sides, without the slightest means of ascent? A bear in a pit would be in a happy state in comparison. If ever there was an unfounded cry of alarm raised against the improvement of

the means of communication, this was one of the most extraordinary. If it were said you should not publish Ordnance maps, he could understand it; that was offering the enemy information which he could not otherwise obtain, and no doubt every officer on the Continent knew perfectly well all our means of communication. If it were said you must not have harbours to accommodate vessels of large size, he could understand that; for that might be a source of danger; but when it was a question of a tunnel 150 feet below the sea, with the power of flooding it without permanent injury, at any moment and to any extent, and also with the power to prevent any one getting up from it to the ground level, it did seem to him that the military scare must have arisen because the facts were either not known, or were not correctly appreciated.

Colonel HOZIER, in reply, said he had purposely abstained from going into the commercial element of profit, because, as the Chairman had said, that was simply a matter for the shareholders to consider. If the people of this country did not feel sufficient confidence in it it would not be made, but if they did, and the other obstacles were removed, it would. The Government had no more right to prevent the tunnel being made because it would not pay than they had to prevent the public investing in a railway, a steamboat company, a mine, or anything else. As to the Manchester Ship Canal being an argument against the tunnel, he considered it just the reverse. The great object was not to make a tunnel but to have direct communication without breaking bulk, and if that could be got in any other way so much the better, but he did not see how. A ship canal from London to Paris would cost much more than the tunnel. The broad principle was direct communication, and if that could be obtained by a bridge or by balloons we should be in favour of it. The distributing trade might then be preserved to London, though what had been lost by the improvement of continental harbours would probably not be recovered. It had been said that the military objections had not been fairly met. He could only say that he had studied carefully all the reports of the Commissions, and the evidence of the military experts, and had had the honour of discussing the matter with very high military authorities, and he did not think he could reproach himself with having passed over any argument brought against it; if he had, it was quite unintentionally. He desired simply to put the argument fairly before the meeting and the public, and that every man who had an interest in the welfare of the country should think this subject out for himself. He did not care whether the opinion he formed were favourable or adverse, so long as he formed it after careful and mature deliberation.

The CHAIRMAN then proposed a vote of thanks to Colonel Hozier, which was carried unanimously.

Mr. OLIVER J. WILLIAMS writes in continuation of his observations in the discussion :—

May I add a few words to Wednesday night's discussion on the Channel Tunnel. Sir F. Bramwell, in replying to my questions, rather strengthened my case, for if the mouth of the tunnel could be so easily flooded, an enemy once having captured Dover Castle (or the controlling fortress) could as easily re-open the tunnel, and so obtain the one essential to invading England, a safe basis of supply and communication, and this in spite of our navy still controlling the sea; moreover, if the opening to the tunnel is as far inland as suggested, there will be the greater difficulty for our fleet to bombard it, and help to recapture the position if once taken by the enemy.

Commercially, is it not the Customs tariff, and cheaper continental labour, rather than the freight, which prevents our profitably sending goods to the Continent; also continental harbour improvements, and other shipping facilities for direct imports from the Colonies, India, &c.?

On the other hand, would not French eggs, milk, vegetables, &c., become by the train route increasing competitors to the suffering English agriculturist? Indeed, all continental goods made by its cheaper labour might be brought into increased competition with our English manufactures, not only in the Home but in the Colonial and Indian markets. These questions I do not intend to answer, but they are important ones, which were I think last night omitted. Indeed, most interesting as Colonel Hozier's paper was, it seemed to me to skilfully avoid the great national dangers, both commercial and defensive, which must be duly weighed if a clear judgment is to be formed.

Miscellaneous.

SOUTH KENSINGTON AND BETHNAL-GREEN MUSEUMS.

There has been a very marked increase in the number of visitors to the South Kensington Museum during the last year, the numbers rising from 788,412 in 1887, to 896,225 in 1888. But the increase of 108,813 is quite put in the shade by that of 500,582 at the Bethnal-green Museum, which in its total of 910,511 for the past year has, as will be seen, distanced the parent institution. This great influx of visitors, more than double that of the previous year, is attributed in great measure to the exhibition there of her Majesty's Jubilee presents, after they had

been shown to the West-end at St. James's Palace. But some part of the increase must be attributed to the fine collection lent by the Hon. W. F. B. Massey Mainwaring.

The increase in numbers at South Kensington was not confined to the main museum, but extended to the separate collections—the Science Museum and the India Museum—which are in the galleries at the west side of Princes-gate, and which are not open in the evening as are—on three evenings in the week—the collections in the main building on the east of Princes-gate, and the Bethnal-green Museum. The numbers visiting the science collections increased from 177,465 in 1887, to 251,796 in 1888, notwithstanding the fact that the galleries have been severed by the new road cut across the Horticultural-gardens, while the visitors to the India Museum increased from 116,574 to 152,911. The number of visitors are taken in all cases by turnstiles.

THE SILK INDUSTRY OF MILAN.

The *Journal de la Chambre de Constantinople*, quoting from the report of the Milan Chamber of Commerce, says that the manufacture of mixed tissues is effected in the Milan district less by hand than by machinery, which was introduced into Italy ten years ago by a Milan house. The results of the introduction of this machinery have been most fortunate, for the establishment in question, being chiefly devoted to the production of stuffs for umbrellas, was enabled to so perfect their production, and to reduce the cost in such proportion that they were soon in a position to export a very large quantity of their goods to foreign countries, where they are greatly appreciated. The success achieved by this firm from the employment of machinery on a large scale encouraged other persons to follow their example, and at the present time there are 665 power looms in the country, of which thirty are at Milan, a number not exceeded in any other district of Italy, with the exception of Como. To give an idea of the importance of the production, it may be stated that the quantity of stuffs manufactured by these looms amount in a single year to 1,800,000 metres. As regards the raw material employed in the production of Milanese tissues, both of pure and of mixed silk, it appears that the silk itself is almost always of Italian production; *per contra*, the cotton used in mixed tissues ia partly supplied by Italian spinning mills, but only in the case of the lower numbers, while for the fine mixed tissues requiring threads of a higher number than forty or fifty, the cotton is brought from abroad, and chiefly from England. The silk manufactures of the Milan district are partly consumed in Italy and partly exported, chiefly to Austria, France, Germany, England, and the United States. The Milan Chamber of Commerce has frequently pointed out how important have been the exports of silk for cravats, but at the present time the bulk of the exports consists of all silk stuffs for women's dresses, and stuffs of pure and mixed silk for umbrellas. As regards the exports of mixed silk tissues from Italy, it is stated that the returns are somewhat defective. According to the official returns they are as follows:—In 1881 and 1882, 2,000 kilogrammes; in 1883 and 1884, 3,000 kilogrammes; in 1885, 6,000 kilogrammes; and in 1886, 12,000 kilogrammes, while the Milan Chamber of Commerce affirm that from the neighbourhood of Milan alone more than 30,000 kilogrammes were exported in 1885, and the amount has been greatly increased. The total number of workpeople employed in power-loom weaving is 2,785, of whom 700 are in Milan, and the remainder in the ten communes where factories have been established.

AGRICULTURE IN FINLAND.

Finland has an area of 375,000 square kilometres, the entire surface being intersected by innumerable lakes, which comprise about 10 per cent. of the whole. Her Majesty's Consul at St. Petersburg, in his last report, says that about 60 per cent. of land in Finland is forest land, whilst marsh and bog take up another 10 per cent., so that there is, as yet, only a small proportion under cultivation. The State owns about half the woodlands, which are under proper management, whereas the private forests have been somewhat recklessly treated hitherto. Pine, fir, and birch are the commonest species. Granite covers the greater part of the country, having an upper stratum composed of fragments of rock mingled with gravel, sand, clay, and animal and vegetable matter, but the more fertile portions have been reclaimed from moor and marsh. The climate, owing to the proximity of the sea, is mild compared with North Russia and some other countries in the same latitude, yet the ground is usually covered with snow during four or five months of the year, whilst more inland, and far up in the north, the winter lasts at least a month longer. The summers are, consequently, short, though sometimes very hot. The population of Finland, in 1885, was 2,250,000, of whom 80 per cent. are engaged in agricultural pursuits, and of these the vast majority are peasant proprietors. According to the latest published returns, only 1,108 proprietors owned more than 250 acres of land each, 10,276 owned between 60 and 250 acres, 57,450 owned between 12 and 60 acres, and 42,592 possessed less than 12 acres each. Tenants of State lands have a hereditary right to their farms on certain conditions, and can even purchase these farms on easy terms, and so become proprietors. Rye is the principal grain grown, and

forms the staple food of the population; potatoes are also extensively cultivated. Rye is sown in autumn, and oats and barley in spring, as soon as the snow melts. Finnish rye is much prized for seed, and considerable quantities are exported to Russia and Sweden for that purpose. Agricultural machinery of the simpler and cheaper descriptions is used wherever possible, but as small holdings are the rule, and large plains or even fields quite an exception, the employment of reapers and similar implements is attended with many difficulties, not the least of which are the rocks and stones that abound on all sides. Finland possesses two agricultural colleges, and eight smaller schools subsidised by the State. There are also fifteen small dairy schools and two higher dairy schools, these latter forming departments of the agricultural colleges. Dairy farming has recently shown a very great development, owing to Government encouragement on the one hand, and to the unremunerative prices of cereals on the other. England is the principal market for Finnish dairy produce. The native breed of cattle has been much improved of late years by the importation of Swiss and English breeds. The horses of Finland, like those of Scandinavia in general, are small and thick-set, but very strong and hardy. As a rule, they are well cared for and kindly treated, and whips, sharp bits, and blinkers are almost unknown. There are at the present time about 2,285,000 acres of arable land, and 3,290,000 acres of meadow land in the Grand Duchy. The following is a description of the simple and practical method employed by the Finlanders for preventing the hay being spoilt by rain. Poles or props, usually of fir, about eight feet long and four or five inches in diameter, and furnished with a few projecting wooden spikes, at intervals of about a foot, are stuck firmly into the ground, and the grass piled around them as in ordinary haycocks, but less bulky. Owing to the ventilation thus supplied the hay suffers comparatively little, even after an exposure of two or three weeks. Consul Mitchell says that the extra trouble and expense are trifling, and the system might easily be tried in England, especially in bad seasons, or on low lands likely to be flooded. The above system is also occasionally used for harvesting cereals, especially oats. As regards agricultural wages, the average prices for day labourers vary from 1s. to 1s. 2d. per day, with food; for women, 9d. to 10d. a day. Monthly wages of farm labourers, with board and lodging, 12s. to 17s.; of women, 6s. 6d. to 8s. Among the many difficulties in the way of the Finnish agriculturist is that of protecting his live stock from the attacks of beasts of prey, the loss reported under that head, for 1880, being as follows: 467 horses, 1,542 head of cattle, 8,939 sheep, 284 pigs, 207 goats, and 3,167 reindeer. In the same year were killed 115 bears, 321 wolves, 301 lynxes, 4,229 foxes, 136 wolverines, 267 otters, and 1,891 ermines, for the destruction of which animals, premiums were paid amounting to about £1,675.

Obituary.

SIR H. A. HUNT, C.B.—Sir Henry Arthur Hunt died at his residence on the Lees, Folkestone, on Sunday, 13th inst. He was a son of Mr. James Hunt, of Westminster, and was born in 1810. He was a partner in the firm of Hunt, Stephenson, and Jones, the surveyors, and held the post of Consulting Surveyor to her Majesty's Office of Works from 1856 to 1886. He was formerly auditor for the Dean and Chapter of Westminster. Sir Henry Hunt was elected a member of the Society of Arts in 1857, and at various times he placed his experience at the service of the Society by acting on committees and otherwise.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings at Eight o'clock:—

JANUARY 23.—"Electric Meters for Central Stations." By PROF. GEORGE FORBES. W. H. PREECE, F.R.S., will preside.

JANUARY 30.—"The Construction of Photographic Lenses." By CONRAD BECK.

FEBRUARY 6.—"The Status of the County Council." By G. L. GOMME, F.S.A.

FEBRUARY 13.—"Salt: its Production and Consumption at Home and Abroad." By PETER LUND SIMMONDS, F.L.S.

FEBRUARY 20.—"The Forth Bridge." By BENJAMIN BAKER, M.Inst.C.E.

March 6.—"Arc Lamps and their Mechanism." By Prof. SILVANUS P. THOMPSON.

FOREIGN AND COLONIAL SECTION.

Tuesday evenings, at Eight o'clock:—

JANUARY 29.—"Gold Mining in Colorado." By THOMAS W. GOAD.

FEBRUARY 19.—"Slavery in its relation to Trade in Tropical Africa." By Commander V. LOVETT CAMERON, C.B., R.N.

MARCH 12.—"Borneo." By ROBERT PRITCHETT.

APPLIED ART SECTION.

Tuesday evenings, at Eight o'clock:—

JANUARY 22.—"Some Recent Movements in Relation to the Applied Arts." By SIR JAMES D. LINTON, P.R.I. SIR PHILIP CUNDIFFE-OWEN, K.C.B., K.C.M.G., C.I.E., will preside.

FEBRUARY 5.—"Manufacture of Sèvres Porcelain." By EDOUARD GARNIER.

FEBRUARY 26.—"English Bookbinding in the Reign of Henry VIII." By W. H. J. WEALE.

MARCH 19.—"The Art of the Jeweller." By CARLO GIULIANO.

INDIAN SECTION.

Friday evenings, at Eight o'clock:—

JANUARY 25.—"The Asiatic Colonisation of East

Africa." By H. H. JOHNSTON. MAJOR-GENERAL SIR FREDERICK J. GOLDSMID, K.C.S.I., C.B., will preside.

FEBRUARY 15.—"The Ruby Mines of Burmah." By G. SHELTON STREETER.

MARCH 8.—"The Present Condition and the Prospects of Indian Agriculture." By PROF. ROBERT WALLACE.

MARCH 29.—"The Progress of the Railways and Trade of India." By SIR JULAND DANVERS, K.C.S.I.

CANTOR LECTURES.

The following courses of Cantor Lectures will be delivered on Monday evenings at Eight o'clock:—

ALAN S. COLE, "Egyptian Tapestry and Textiles." Two Lectures.

LECTURE I.—JANUARY 21.—Textiles discovered at Akhmîm in Upper Egypt—Varieties of patterns in them, showing successive influences—Greek—Græco-Roman—Syrian—Christian-Coptic; Sketch of Egyptian intercourse with foreign countries from end of 26th (Saite) dynasty to Arab invasion 7th century A.D.; Simple weaving in Egypt—Shaggy-faced textiles compared with the Greek *Kaunakes* and Roman *Gausapum* — Embroidered linens; Tapestry-weaving process described by Ovid, and used by inhabitants of Akhmîm for decoration of costumes—Corresponding use of same process by natives of Peru during the Inca Empire—Silk specimens from Akhmîm.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, JAN. 21...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. Alan S. Cole, "Egyptian Tapestry and Textiles." (Lecture I.)

Medical, 11, Chandos-street, W., 8½ p.m.

Asiatic, 22, Albermarle-street, W., 4 p.m.

Victoria Institute, 7, Adelphi-terrace, W.C., 8 p.m. Prof. Leitner, "Investigations in the Science of Language and of Ethnography."

London Institution, Finsbury-circus, E.C., 5 p.m. Mr. A. A. Common, "Astronomical Photography."

TUESDAY, JAN. 22...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Applied Art Section.) Sir James D. Linton, "Some Recent Movements in relation to the Applied Arts."

Royal Institution, Albemarle-street, W., 3 p.m. Prof. G. J. Romanes, "Before and After Darwin." (Lecture I.)

Medical and Chirurgical, 53, Berners-street, Oxford-street, W., 8½ p.m.

Civil Engineers, 25, Great George-street, S.W., 8 p.m. Adjourned discussion on Mr. Edgar Worthington's paper, "The Compound Principle as applied to Locomotives."

Anthropological, 3, Hanover-square, W., 8½ p.m. Annual Meeting. Address by the President, Mr. Francis Galton.

WEDNESDAY, JAN. 23...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Prof. George Forbes, "Electric Meters for Central Stations."

Geological, Burlington-house, W., 8 p.m. 1. Dr. James Croll, "The prevailing misconceptions regarding the evidence which we ought to expect of former Glacial Periods." 2. Mr. R. Lydekker, "Remains of Eocene and Mesozoic Chelonia, and a tooth of *Ornithopsis*." 3. Messrs. R. Etheridge and H. Willett, "The dentition of *Lepidotus maximus*, Wagn., as indicated by specimens from the Kimmeridge Clay of Shotover-hill, near Oxford."

Royal Society of Literature, 21, Delahay-street, S.W., 1 p.m.

Civil and Mechanical Engineers, Westminster Palace Hotel, S.W., 7 p.m. Mr. E. L. W. Hoskett-Smith, "Boring for Petroleum in Galicia, Austria."

Cymmrodorion, 27, Chancery-lane, W.C., 8 p.m. Mr. R. H. Williams, "Some Minor Welsh Poets of the Georgian Era."

United Service Institute, Whitehall-yard, S.W., 3 p.m. Captain W. H. Sawyer, "The Recent Changes in the Drill of the German Army."

THURSDAY, JAN. 24...Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

London Institution, Finsbury-circus, E.C., 6 p.m. Rev. Canon Benham, "The Times of the Twelve Cæsars."

The Sanitary Institute, Parkes Museum of Hygiene, 74A, Margaret-street, W., 5 p.m. Dr. G. V. Poore, "London, Ancient and Modern, from a Sanitary Point of View."

Royal Institution, Albemarle-street, W., 3 p.m. Prof. J. W. Judd, "The Metamorphoses of Minerals." (Lecture I.)

Electrical Engineers, 25, Great George-street, S.W., 8 p.m. Prof. A. Jamieson, "The Insulation Resistance of Electric Light Installations."

FRIDAY, JAN. 25...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Indian Section). Mr. H. H. Johnston, "The Asiatic Colonisation of East Africa."

United Service Institute, Whitehall-yard, 3 p.m. Lieut. Warren F. Caborne, "The Royal Naval Reserve."

Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting, 9 p.m. Prof. G. H. Darwin, "Meteorites, and the History of the Stellar Systems."

Civil Engineers, 25, Great George-street, S.W., 7½ p.m. (Students' Meeting.) Mr. W. W. F. Pullen, "Water Softening and Filtering Apparatus for Locomotive Purposes, at the Taff Vale Railway Company's Penarth Dock Station, near Cardiff."

Quekett Microscopical Club, University College, W.C., 8 p.m.

Clinical, 53, Berners-street, W., 8½ p.m.

Browning, University College, W.C., 8 p.m. Paper by the Rev. W. Robertson.

SATURDAY, JAN. 26...Physical Science Schools, South Kensington, S.W., 3 p.m. 1. Prof. S. P. Thompson, "Notes on Polarised Light, on the Structure of Natural Diffraction Gratings of Quartz, on Ahren's Modification of Delezenne's Polarizer, and on the use of two quarter-wave plates in combination with a stationary Polariser, and Note on a relation between Magnetisation and speed in the Dynamo Machine." 2. Prof. E. F. Herroun, "The Divergence of Electro-motive Force from Thermo-chemical Data."

Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Prof. Ernst Pauer, "The Character of the Great Composers, and the Characteristics of their Works." With Pianoforte Illustrations. (Lecture I.)

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FRIDAY, JANUARY 25, 1889.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

SWINEY PRIZE.

A meeting of the adjudicators of this prize, appointed by the will of the late Dr. Swiney, was held on January 21st, 1889, at the rooms of the Society of Arts. Sir Frederick Bramwell, Bart., F.R.S., Vice-Chairman of the Council, in the chair.

The Secretary read the advertisement convening the meeting.

The Secretary read a report from the Joint Committee of the Society of Arts and the College of Physicians, recommending that the prize should be awarded to Charles Meymott Tidy, M.B., for his work entitled, "Legal Medicine."

It was thereupon moved by Sir Frederick Abel, C.B., F.R.S., Vice-President of the Society, and seconded by Dr. Wilkes, F.R.S., Censor of the College of Physicians, and carried, "That the prize, a silver goblet, value £100, containing gold coin to the same amount, be adjudged, and the same is hereby presented, to Charles Meymott Tidy, M.B., F.C.S., the author of a published work on Jurisprudence, entitled "Legal Medicine."

The cup has been executed by Messrs. Garrard, from a design made expressly for the Society by the late Daniel Maclise, R.A.

CANTOR LECTURES.

Mr. Alan S. Cole delivered the first lecture of his course on "Egyptian Tapestry," on Monday evening, 21st inst.

The lectures will be printed in the *Journal* during the summer recess.

Proceedings of the Society.

APPLIED ART SECTION.

Tuesday, January 22, 1888; Sir Philip Cunliffe-Owen, K.C.B., K.C.M.G., C.I.E., in the chair.

The paper read was—

SOME RECENT MOVEMENTS IN RELATION TO THE APPLIED ARTS.

By Sir James D. Linton, P.R.I.

In the paper I shall have the honour to read to night, I have not been so happy as I could wish in my choice of a title, inasmuch as it does not quite express the aspects of the subject I propose to treat. I may at once say that I shall not speak of the applied arts from a technical point of view, but shall rather endeavour to deal with the various opinions that have lately been given forth upon the subject.

During the last month, an event has occurred singular in the history of art. I refer to the congress recently held at Liverpool, to discuss the past, present, and future of art, and matters vital to its well-being.

This the first I trust of many such annual meetings, was held in December last, under imposing circumstances and with a gathering of men distinguished in the various branches of art. One of the most important of the sections of the congress was that of "Applied Art," a branch that is of immediate concern to the body of the people of this country and to this Society, inasmuch as it enters into the daily life of us all. We must all respect and honour the motives that have actuated the initiators of this movement, and that they have the best interests of art as the pivot of their action will be readily allowed, but I venture to suggest that great difficulty will be experienced in giving a practical issue to so important an undertaking. The widely different opinions on what must be in many cases questions of theory will certainly tend to confuse the public mind, unless some method can be devised to digest and present those opinions in some practical form.

I cannot help feeling that the initial mistake of the Congress was its general tone. It was one long Jeremiad, in which what Burke declared to be impossible was attempted, and an indictment laid against the whole British nation, those only being excepted who are

professionally connected with art. The vast majority of the outer world were in all directions accused of a want of due appreciation of the beautiful, of a lack of national spirit towards the encouragement of art, and of a proper pride in the results of our art progress. But the members of the Congress did not point in sufficiently strong terms to the share of blame that may be properly attached to themselves for this state of things. Many will think this not only unfair but also unwise, as the first object should naturally be to attract the sympathies of all to the movement by a just presentment of the case. "The voice is the voice of Jacob, but the hands are the hands of Esau." If, however, the people are wanting in this appreciation of art, how much more blameworthy must be a want of appreciation in the artists! Ought they not, by reason of their education and profession, to be the pioneers in every artistic movement, and ought they not to be the first by their knowledge to discover and bring to the front all workers in art truly worthy of honour? Does the history of our national art tell us that this is the case? How many men could we not mention who have lived unhonoured and comparatively unknown, not so much from the want of due appreciation by the people as from the want of appreciation on the part of their brethren, who ought to be the people's guides and leaders? Are we altogether free from the reproach even at this time?

To open the Congress with dignity it was but right and proper that the presidential chair should be filled by one who, by his knowledge and practice in art, and by his position, should give to its deliberations the assurance to the public of its important character. It was not difficult to arrive at the conclusion as to who that person should be, and as all interested could have wished and foretold, Sir Frederick Leighton, the President of the Royal Academy, was the choice of those whose duty it was to see the office adequately filled. Better filled it could not have been. Sir Frederick is not only eminent in art as a painter but also as a sculptor, and he has the additionally valuable qualification that he has devoted a large amount of sympathetic labour towards the advancement of the applied arts. The proof of Sir Frederick's ample response to the call made upon him, is the very able and exhaustive address which he delivered on the day of the opening of the Congress, but exhaustive and learned as that address was, I feel that even Sir Frederick has not quite placed matters in their true light, and, unfortunately his argument was reflected in the addresses of the speakers who followed him. The praise and the blame were not rightly adjusted as between the artist and the public, and we are asked to believe that any demand from the latter can be supplied. As well might one say that, upon due encouragement, Michael Angelos, Titians, and Rembrandts will appear in our midst. These, I am sure, will be the conclusions arrived at by the public, not only from the general tone of the congress, but from the matter of many of the papers, and the arguments used in the president's opening address. The principal charge made by Sir Frederick was that, as a nation, we were absent in the strong æsthetic instinct, the impulse towards and absolute need of beauty, that although what was excellent received recognition, that which was ignoble and hideous was not detested, but was indeed accepted with a dull, indifferent acquiescence. Curiously enough, he contradicts this statement in another part of his paper, by the significant remark that the consciousness of which he spoke was rather dormant with us than absent. The charge, however, is a serious one, and would be terrible if it could be borne out in its entirety. But let us consider from historical facts whether this dull acquiescence and indifference is the element most at work in the spirit of the people. Art must grow from within outwards, and to bring forth appreciation something must previously be produced worthy of that distinction. If one were able to point to any great and noble art movement which had failed from want of due appreciation, that might be adduced as a proof of the dulness of the people. I venture to make the assertion that the charge cannot be sustained by historical facts, but that everything tends to point to the contrary. Of course it could be said that if such and such arts had been encouraged they might have been worthy; but this is begging the question, as other causes may have been at work to prevent their fruition quite outside that of want of appreciation. The particular phase of art may have been foreign to our wants, to our time, to our surroundings. It would be certainly easy to prove that the English race has always shown a most worthy and keen appreciation of the beautiful, even of the highest kind. Going back to the various periods of English mediæval art down to the time of Henry VIII., could a people wanting in the pure æsthetic

instinct have evolved such architecture as that of the 13th century, the most beautiful of all the examples of that style, and which had attached to it art crafts of all kinds, of the highest degree of excellence and beauty? Then came the great revival, when the influence of classic art first made itself generally felt outside Italy, the country where its highest then known forms were present. It was essentially the period of revolution, the reflex of a new world of thought, dating in England from the latter half of the reign of Henry VIII., and culminating in the reign of Elizabeth, that golden age of our literature and music. Co-incident with them, architecture and the applied arts reached a high point of excellence, and were distinctly national in their adaptation. This influence continued with very marked advances down to that time of disaster to the arts, the period of the Commonwealth. This great revolution, though it undoubtedly brought many blessings in its train, was fatal to the arts. It was one long-continued blight. Many years had to elapse before they began to show signs of recovery. But even through this period of trial there was always evidence of a strong vitality which only wanted opportunity to blossom forth, such as that which produced men like Sir Christopher Wren, and with him a band of art workmen of whom we have reason to be justly proud, continuing on to the advent of the latter phases of the style as exemplified by the productions of Sir William Chambers, a contemporary of our distinctively national painter Hogarth. During all these periods there are innumerable examples of the applied arts of high quality, showing that they were still a living force, and most important of all, that they were a national expression of our social life.

Coming down to our own times, where was the Greek revival of the end of the last, and the beginning of this century, more keenly felt and more strongly encouraged than in this country? One of the most remarkable movements of that time was the creation of Englishmen, and its influence was felt all over civilised Europe. I am referring to the work carried out by Wedgwood, in conjunction with Flaxman and others. All acquainted with the character of this work know that it requires great refinement of mind, and a very strong feeling for the beautiful, to be appreciative of its merits. Was this phase of art the appanage of the few? On the contrary, it was made for and appreciated both by the few and the many. There was hardly a family in this country who did not possess and cherish specimens of the work, and the style of it pervaded all the surroundings of the homes of that time, furniture, stuffs, metal, pottery, were all directly influenced by this peculiarly elegant emanation, a style that relied more than any other art movement upon the purity and beauty of its forms. So far from showing a dull acquiescence in the ignoble and the hideous, I am sure that the peculiar instinct of the English race is towards the beautiful and the pure, as witness our noble literature in poetry and prose. That we have at times been acquiescent from despair may be true, but not from dulness. Having briefly passed in review some of the principal epochs of our art history of the past, we will now turn to that period of more immediate interest to us at this time.

From 1815, a most extraordinary wave of degeneration gradually overwhelmed the applied arts, not only in this country, but throughout Europe. The horsehair and mahogany furniture, the mantelpiece lustre, and the Carrara-marble vase reigned supreme. It seemed as if the degeneration of design in the applied arts could sink no lower without absolute dissolution. But even at this unhappy time some branches of the arts served to preserve it from extinction, notably in the art of painting, as this was the period when the genius of Turner, Constable, and the great water-colour painters of our national school were at their zenith, and they, through all adversities, held aloft the torch that was to be the means of revivifying the sister arts. For some time there appeared but little hope of a recovery from that lethargy which seemed to envelop such as remained of the applied arts, but the awakening came at last with the advent of the exhibition of 1851, which gave us the opportunity of measuring our strength with other nations, and bringing our deficiencies into the broad light of day, and to the bar of public opinion. For this great blessing we must always revere the memory of its initiator, the late Prince Consort.

Fortunately, through all this later period of comparative absence of design, our workmen were still, as handicraftsmen, amongst the first of their kind. Their work had the solid and thorough treatment that has always distinguished the best work of this country. We had, and we still have, a body of workers who, with proper direction and due encouragement, have capacities to carry to a successful issue

any calls that may be made upon them, and in no sense can they be held to blame for the retrogression that had taken place in the applied arts, a retrogression due to the degeneration in design, and it was this branch—the life of the arts—that the Exhibition of 1851 was so valuable in re-awakening. If Sir Frederick Leighton's address had been delivered at that time, all must have admitted the force of his arguments; but when we look around, and see the advance of design, and the uses of the applied arts since that date, when we see how intimately they are associated with our everyday life, then we must feel that the statements in the address seem somewhat strained and over-emphasised, and this must be especially evident to those who can remember the applied arts previous to 1851.

The causes of this period of decadence are not far to seek. All Europe had just gone through a long and ruinous war which had impoverished the nations, and used up and exhausted the people. Trade of all kinds had suffered severely, and a heavy bill had to be met, the consequence of which was a disastrous period of commercial depression.

Buckle, in his "History of Civilisation," has justly said, "Art can only flourish upon a soil sown with gold," and, as must inevitably result from stagnation in trade, art was the first to suffer, and it was not until prosperity was restored, and the applied arts came again into demand, that they could regain the position they ought rightly to fill.

In time, the evil effects of the great Napoleonic wars subsided; that stormy period was succeeded by the forty years' peace, and by a new era of commercial prosperity most beneficial towards increasing the resources of this country, resources which rapidly became immeasurably greater than at any previous period of our history. The display at the Exhibition of 1851 emphasised this fact with the greatest force. Material prosperity was at that time at its zenith; but the applied arts had, alas! degenerated so much as to become the mere instruments of vulgar display. Those who can remember the state of these arts immediately preceding 1851 will, I am confident, bear me out in my statement. I would ask all whose acquaintance with those arts dates subsequent to that eventful year to look through the illustrated catalogue of the Great Exhibition, and I am confident that they also will agree with my estimate of the state of the applied arts at that time.

Sad though the condition of the applied arts in general then was, there had come into existence some few years previously the first signs of a return to the right direction in the advent of the modern Gothic revival, the honour of which was mainly due to that distinguished architect, Augustus Welby Pugin, and whether we come to the conclusion that it did or did not fulfil all the requirements of modern life, the important fact remains that it had the distinction of having revived an earnest endeavour towards the beauties of style, refinement, and honesty of purpose. It was also indirectly, and in conjunction with other influences, the cause of many of the applied arts being revivified, and its influence in ecclesiastical art is still paramount.

The knowledge gained from the Exhibition of 1851 gave great impetus to all the art crafts, for not only did it recall to life many that had ceased to exist in this country, but those which already existed received such a stimulus, and the encouragement bestowed upon them became from year to year so increasingly marked, that it must be little short of astounding to those who are deeply acquainted with the history of their revival.

I know of no branch that has since that time languished for the want of due appreciation on the part of the people; on the contrary, every sign tends to show that it is only the want of more advancement in the producers that will prevent even increased encouragement in the future from the art-loving public. We have only to look around to see, not perhaps perfection, but at least such advances on the period previous to 1851 as to justly convince us that the people of England are as receptive of the beautiful as any other nation of our time. That there are large numbers in whom, by reason of the limitations of their character or training, fine taste is absent is most true, but in that misfortune we are not singular. Even among the Greeks, the most artistically gifted nation of all time, it was only in certain States, and among the select citizens of those States, that anything like a genuine taste or appreciation of art can be shown to have existed. But whatever deficiencies still exist I would lay at the door, not of the public, but of the art crafts themselves, and the remedy for those deficiencies must proceed, not from the public, but from the designer and the workman. In this connection and for this purpose it would be difficult to over-estimate the great benefit that would result from a more intimate association of the two, but it is, unfortunately, always much easier to point

out a weak spot than to cast upon its remedy. How can this isolation of designer from workman be best diminished?

The art-workman has been lectured times out of number, but I fear that the impression left upon his mind by most of the addresses to which he has listened has been, that they were very able from a bookman's point of view, but too theoretical and too abstruse to produce any growth in a mind that requires something of a more immediately substantial nature than mere words. The major part of these addresses have consisted too much of the Utopian; they have been the expression of vague theories on art, the outcome partly of ignorance, partly of good intentions, and only fractionally of any real skill or personal acquaintance with the productive aspects of the subject. Nothing can well be conceived less fitted to appeal to men who, by nature, habit, and necessity are eminently practical in their reasoning. As Macaulay writes, "An acre in Middlesex is better than a principality in Utopia; the smallest actual good is better than the most magnificent promises of impossibilities." The more it is understood and acknowledged that our social life governs our art, the sooner, by using properly the forces of that life, shall we arrive at the goal we are striving to reach. We waste valuable energies by playing the part of Cassandra, and however eloquent may be the diatribes which are levelled against the evils of the time in the shape of machinery and the modern methods of reproduction, the thoughtful man knows that only by using present forces can the best, or indeed any really living and permanent results be attained. The constant railing against our modern civilisation by those connected with the arts gives them the unfortunate appearance of trying to put back the hands of time. That evils exist in our age is undoubted, but we must look at it as a whole to be able to judge whether it has, as compared with past times, failed in that primary requirement, the securing of the greatest good to the greatest number. That it has not done so is the opinion of many of our wisest; and here I will again quote from Macaulay, who illustrates the subject thus:—"It has lengthened life; it has mitigated pain; it has extinguished diseases; it has increased the fertility of the soil; it has given new securities to the mariner; it has furnished new arms to the warrior; it has spanned great rivers and estuaries with bridges, of form unknown to our fathers; it has guided the thunderbolt innocuously from heaven to earth; it has lighted up the night with the splendour of the day; it has extended the range of the human vision; it has multiplied the power of the human muscles; it has accelerated motion; it has annihilated distance; it has facilitated intercourse, correspondence, all friendly offices, all dispatch of business; it has enabled man to descend to the depths of the sea, to soar into the air, to penetrate securely into the noxious recesses of the earth, to travel the land in cars which whirl along without horses, and the ocean in ships which run ten knots an hour against the wind. These are but a part of its first fruits."

In addition to all these benefits, our modern movement has given to us civil and religious liberty. All these blessings have become more and more the possession and enjoyment of the whole people with the circumstances of our modern methods. Can art expect, in the face of such facts, that she alone is to be uninfluenced? No power of words will ever reverse the inevitable. The efforts of art should be directed towards using all the instruments a wise Providence has placed within her reach. If modern machinery has produced a new chaos, it ought to be the function and the pride of art to evolve a new order and a new beauty out of it.

Art craftsmanship is only to be taught by demonstration. You may create emulation by words—a very desirable spirit to awaken, but if work is the desideratum, by work alone can it be produced. An intelligent art workman learns more by the examination of the masterpieces of his art than by all the words that were ever written or spoken, and it is the intelligent few who leaven the mass. That by the inevitable law of change certain phases of art have ceased to be living powers is most true, but there are branches belonging to this nineteenth century which will be held up to honour and gratitude by our successors.

Isolation of designer from craftsman, and craftsman from craftsman, I believe to be one of the causes of our not having a more extensive improvement in the quality of our art work. In our craftsmen we have a body, perhaps the most amenable, certainly the most painstaking and trustworthy in the world, and it is to be regretted that there are so few means by which they can be brought together after their daily work to compare, and to discuss the various characteristics of their particular crafts by which they could further a general improvement. There are societies connected with many of the crafts, but they are either of

a purely commercial character, or are of the the nature of benefit societies. I would suggest that each craft should return to a modified form of the best features of the old guilds, adapting their old constitutions to suit modern needs, and applying these revived guilds solely and entirely for the purpose of improving the character of their work, both as an art and a craft.

The Society of Arts has always played an important part in endeavouring to promote the welfare of the applied arts. If the members of this Society were to consider the practicability of this idea, it is possible that much might be effected towards producing results which they are always anxious to initiate and to aid. We are suffering from the want of organisation, and we are also suffering from a further evil of a vital character, namely, the increasing repugnance to the use of the grade of apprenticeship, a means of training so valuable that I fear, unless the decay of this method by which our race of craftsmen has up till now been continued be arrested, disastrous results will ensue. I may remark that a body somewhat similar in character to that which I have here sketched, already exists in the Art Workers' Guild, of which I have the honour to be a member. The reason of its existence is to bring together all practical workers in the various branches of the applied arts for mutual instruction and enlightenment. This is principally carried out by lectures, but differing essentially from ordinary lectures on art, inasmuch as they are delivered by men who are workers in the branch upon which they are called to speak. Moreover, the lectures which they deliver are demonstrated by actual work, and sometimes the work is executed in sight of the audience. This I consider to be the ideal of what such lectures should be; some such method, in fact, I believe is the only one by which we can secure any true artistic advance in the practical arts. The rules of this society are admirably adapted for extension to the proposed guilds, with the following variations: — Instead of a conglomeration of all the crafts, I would have each craft with its own particular guild. It should consist of members and officers—the officers to be elected from those who have passed as worthy masters of their craft, and it should be the right of all workers in each particular craft to belong to their own guild. There should, in addition, be a governing guild to be the means of communication between all the different crafts, the members of which should be elected by and from the members of the craft guilds. Some of the uses of the governing guild should be to encourage trial works in the different crafts, and the holding of displays of the results. The whole aim of the various bodies should be the encouragement of practical proficiency in the crafts, and the conferring of due honour on those displaying such proficiency, and the membership should be strictly confined to practical workers in the different crafts, whether of design or execution. The amateur element should be studiously excluded.

I have sketched very briefly what, to my mind, would fill an evident void. Whether it would be a practical solution of the question, experience only can determine. At least it is not outside the range of possibility, and does not attempt to reverse the order of modern progress by desiring to abolish the printing-press because it has, unfortunately, helped to destroy the beautiful art of caligraphy, or the locomotive, because of certain evils which have attended its introduction, without weighing in the balance the benefits which the one has conferred in the extension of knowledge, or the other by giving us amongst other innumerable benefits the means of enjoying the loveliness and the health-giving influences of places that without its aid would be quite beyond our reach. To machinery we owe many of the appliances for the alleviation of distress both of mind and body, and to such vast powers who shall say, "Thus far shalt thou go, and no farther." It is rather our duty to use all the means placed at our disposal by an all-wise Providence, and so multiply the blessings always ready to our hand, if we have only the foresight to comprehend them.

DISCUSSION.

Sir George Birdwood, M.D., K.C.I.E., said he was always ready to respond cordially to any demand made by Sir P. Cunliffe-Owen; but he was quite unprepared to speak on the present subject. Nor was he entitled to do so. He had paid close attention to the history of the industrial arts of India, but could not presume to say much on the many complex questions concerned in the development of English arts. He could only express his great gratification that Sir James Linton had responded to the invitation of the Applied Art Section by opening the session with so able a paper. His own sympathies went very much with the speakers at the Liverpool Congress, though he was not disposed

to underrate the merits of the English workman or the taste of the English public. A people who had produced such a body of glorious literature could not be deficient in the artistic sense. At the same time they certainly tolerated a good deal which was very inartistic. He did not look on London as a desert of hideousness, as some recent critics had described it, for it was really, in many of its aspects, one of the grandest spots in the world; but we certainly allowed it to be disfigured in all sorts of unaccountable ways, as by overhead wires, and by plastering our railway stations over with advertisements, and by framing municipal laws which rendered impossible the development of a true national architecture. He passed through Oxford-street every day, and he must say he much preferred it as it was twelve years ago to what it was now that it was supposed to be improved. There was no doubt that architecture had made great advances in that period, but under the municipal rules governing London the architect had no scope. A number of large buildings had been put up at the end of Oxford-street, but owing to their being not allowed to encroach on the pavement, they all looked like so much embossed cardboard, with no variety or beauty of surface. When, therefore, he turned down South Molton-street, he found it quite a relief to look at the old-fashioned frontages which twenty years ago he despised. Native talent, when it did show itself, received but slight encouragement. Wedgwood ware had been referred to, but he did not think the South Kensington Museum possessed a single example of it. Before Flaxman worked for Wedgwood, he had in his employment a Glasgow mason named Tassie, who became distinguished for his pastes, or "gems," as they were often called. They were very common in the shop windows when he was a boy, and he had always bought them whenever he saw them, and had a collection of three or four hundred of them, which he exhibited in Glasgow last year, but not one was to be found either at South Kensington or in the branch museum in Glasgow.

Mr. J. SPARKES said this was too large and complex a subject to be discussed from any one point of view, and probably Sir James Linton's and Sir George Birdwood's contentions were equally right. There were waves of depression in industrial art, and he thought the complaints alluded to in the paper were a passing phase peculiar to the present time. Within the last fifteen years there had been a change for the worse, due to the demand for cheapness; but it must not be supposed that that was going to be a permanent condition of things, and even at the present moment there was evidence that that time of depression was gradually coming to an end. To a very great extent the purchasing power of the middle classes regulated the production of art industries, though no doubt a stimulant could be applied through fashion and the action of cliques; but it was a passing phase, though it tended to a sort of spurious demand for art products, he believed he was right in saying that the nett result of the last fifty years' work was an enormous advance. Only recently he had passed through the street Sir George Birdwood had referred to, and was delighted with its beauty. He thought it one of the most picturesque things he had ever seen, and if any one could compare it with what it was forty years ago, not only in architecture, but what was to be seen in the shop windows, there was an evident improvement. But then it must be remembered that this would be comparing a lively time now with a very dull time then. It was quite certain, however, from the views taken of us by foreign experts, that we had made a great advance. The other day he met with an interesting pamphlet by M. Vachon, in which he gave a mass of statistics showing that the art industries of France were in the greatest possible peril, not so much from the inability to produce good things as to sell them in competition with what was produced by Germany and England. He spoke there very highly of our English system, or want of system, and said it produced the most individual and interesting things in industrial art, to the great danger, in his opinion, of the art and industries which had existed in France for the last 100 years almost without competitors. The artist was naturally an impatient creature, hence these records of his discontent; he wanted to see his work acknowledged and appreciated. It was more or less true in commerce, but not true in art, that demand regulated supply, for he believed that in the case of art the supply created the demand. There were, however, many adverse influences at work. He had been told recently that an artistic trade—that of weaving lace for soldiers' coats, which had existed for 200 years in this country — had been abolished by the action of a Government Department, which insisted on having more and more for less and less money, until at last the trade naturally disappeared and went to Germany. On the other hand, coming into contact as he did with an enormous number of young designers, who, whenever work was slack came straight to him and asked to be provided with employment, he was glad to say that for some months past he had not had a single case on his books which gave him any cause for anxiety. This was one of the signs which might be observed here and there of the steadily rising demand for more or less artistic productions. He was of a hopeful temperament, and believed in English taste, and that our countrymen were able to walk alone when isolated from influences of the Continent. There was character in English work which was perfectly free from any taint of imitation; although there were waves of imitation of Japanese and other things, we gradually worked through them, and still pursued our natural and characteristic course. On the whole, therefore, he thought there was no great cause for anxiety.

Mr. Lewis F. Day said he agreed very much with the paper, although not entirely with what was said about the "Jeremiads" at Liverpool, perhaps because he was one of them who had indulged in what was so described. Sir James Linton said they ought to have spoken more sympathetically, but those who went down there to speak were chiefly artists, and naturally spoke from their own point of view. It was understood it should be a gathering of artists, manufacturers — who were conspicuous by their absence — and others interested in art, so that the matter might be thoroughly thrashed out. The artists and craftsmen naturally put their side of the question as strongly as they could, with the object of provoking discussion; but, as far as a thorough discussion was concerned, the congress was rather a failure. The audience consisted chiefly of ladies, who, though they were interested and sympathetic, did not add much to debate. Reference had been made to the Art Workers' Guild (to which he also had the honour to belong), and he might say that the majority of the papers in the Applied Art Section at Liverpool were delivered by members of that guild. He could not quite agree that the English were the most sympathetic to art of all nations; and, in fact, he was only thinking the other day that it was not much wonder that Englishmen were not colourists, since they so seldom had an opportunity of seeing colour. The year 1851 had been glorified, and in a certain sense it deserved to be, but in another sense it was the death of tradition. Some time ago he saw some manufacturers' pattern-books, some fifty years old, and he was quite astonished to see the art in those patterns, having had no notion there were such good things done in the way of silks and wall-papers. No doubt we had enormously improved since 1851, but could it be said that we had improved in the last five or ten years? Personally, he did not think so. He had been looking, lately, into the fashionable upholsterers' windows, and seeing the most abominable French things displayed as if they were something very beautiful, and he feared they were returning to as depraved a style as if there had been no 1851 Exhibition.

Mr. E. C. Robins, F.S.A., regretted there was such a general feeling of dissatisfaction expressed at the conference at Liverpool, and must say he did not share it, for he thought there had been very great improvement in late years in design and workmanship. What the public suffered from principally was the difference of opinion amongst artists themselves. He could say that in his own craft the most severe critics were those of our own body. One architect who affected one particular style could see no beauty in any other. Mr. Street, who was a very great man, could see little beauty in Classic architecture, and was perfectly ignorant, or professed to be, of the beautiful work that existed in that style. Others were Classicists, and held the same view with regard to Gothic; and these contrary opinions by great men confused the minds of the general public. If a conference could be brought together which, instead of complaining about everything, tried to show how they had moved onwards, and in how much they agreed, the public would be instructed, and would be better able to see what was good and what was bad. He had seen very great changes in architecture in his own time. He remembered when he used to swear by the Grecian, and delighted in the mouldings of that style, but in a few years the fashion changed to Gothic, and he thought and designed in that style with still greater enthusiasm. Whilst Grecian architecture was in vogue he studied it, and when Gothic came in vogue he was bound to study that, and the consequence was that he practised in both styles. With regard to the Gothic architecture, the public generally had an idea that its great distinctive point was that the lines were all vertical, and the arches all pointed, and that there was a peculiar ecclesiastical quality in it. Be that as it might, undoubtedly the great indigenous architecture of this country was Gothic, owing to the fact that at the time those styles prevailed we were cut off very much from other nations, and our workmen and artists were thrown upon their own resources, and were thus led to build things not to be found in any other part of the world. He had gone through a great part of France sketching details of mouldings, and was astonished to see the wonderful similarity that existed in this respect between all the great cathedrals. The variety of mouldings which existed in our own buildings was out of all proportion to the importance of the buildings themselves. There were little churches in various parts of the country which had a greater interest in this respect than anything he knew of abroad. On one occasion, when sketching at a church in Normandy, he was struck with the variety of the work, and on inquiry he found that it had been performed by English workmen. There were many quite exceptional examples to be found in England, and especially during the period of decadence, or the latest period of Gothic architecture. There were no such buildings as Henry VII.'s Chapel or King's College Chapel, to be found elsewhere in the world. They were perfectly distinctive in their design, execution, and in the peculiar character of the fan-groined vaultings, and so on. This period was contemporary with the *flamboyant* in France. He thought there was quite enough evidence existing in our own country to establish the fact that there was no lack of artistic faculty. There were plenty of modern examples of industrial art, such as had been produced by the influence of such men as Sir James Linton, Mr. Day, Mr. Sparkes, or his pupil, Mr. Gilbert, the creator of the statue of the Queen at Winchester. He did not remember having seen any superior to that, either in beauty of design or grandeur of expression. That was what an Englishman did in our own schools,

and showed the result of modern art workmanship. It was not a question of demand, but a question of producing something which would create a demand. When a first-rate man came forward he never wanted work; there were always people who appreciated it, and who were anxious to possess it, and willing to pay for it.

Mr. W. SIMPSON completely sympathised with the tone of Sir James Linton's paper. Having travelled a good deal, he was a little cosmopolitan in his taste, and never could accept the statement that the people of this country had no taste or feeling for art. It was quite true that our art condition was a little mixed, as was evident by the remarks of the previous speakers. There was a great deal to show, and yet there were great defects which required remedying. Time would do that, and what was wanted was good healthy criticism, so that the cause of failure might be better understood. No doubt the people of this country were perfectly qualified to rise to any demand which was required of art, and the action of the Applied Art Section, and the papers to be read there, was one great means of doing that. As to the guilds which Sir James Linton had suggested, he could hardly give an opinion, but he assumed it was a good thing to combine men to act together, and to show them what they should aim at.

Prof. F. E. HULME thought at present we were passing through a period of depression, but anyone who remembered what art was 10 or 20 years ago must see that we were immensely in advance of those times. Of course fashion had its influences, and there were certain objectionable features which cropped up from time to time, but the main body of English art was thoroughly sound. When he was a student at Kensington, they used to attach great value to the teaching of Owen Jones; no doubt his works were excellent, but he thought now there were many Owen Jones's in England. The schools of art had done an enormous amount of good, and though there was a feeling springing up that they had not done as much as they might, and that they were more theoretical than practical, he thought that was a matter which could be put right. Last week he was at Salisbury judging the local papers, and he found the school of art there in vigorous action. It was not only teaching designing on paper, which meant little, but he was shown several designs for carpets, and also the carpets themselves made from the designs, which were very good indeed. The same was true with regard to the designs for lace and for tiles. The question of multiplication by machinery was rather a bugbear, but even that had its advantages, as it enabled an immense number of people to see good work. Wall papers of a good class could be produced now at an exceedingly cheap rate, and everyone gained by the multiplication of good things. Another proof of artistic growth might be seen in this, that there was scarcely a street in London where you did not find a shop full of engravings and photographs, and you always found the largest crowds in front of those shops. He thought the influence of South Kensington had been very beneficial. He had gone through all the various stages there, and was glad to take the opportunity of saying that he owed an immense debt of gratitude to that institution.

Mr. FORBES-ROBERTSON said the paper opened with an admirable historic *resumé*. Coming to the body of the paper itself, what struck him most was the practical turn given to it, viz., that if we were to resuscitate a feeling in the breast of the British workman—a most intractable subject when you gave him an order at all different to what he was accustomed to—what had been suggested was the only method. The City authorities had awoke lately to a sense of this, and had been doing a great deal of good work, as witness the Turners, Plumbers, and others; but it must not be forgotten that in the Middle Ages that was precisely the method adopted. Hence the grand works in iron, lead, gold, and silver with which the *cinque-cento* period was generally associated, although they existed previously. He did not wish to depreciate British taste, and he thought we had no need to go abroad to find great artistic work, at any rate in architecture. Mr. Robins had forgotten to mention that the difference between the French and the English Gothic was not only admirably shown in our English cathedrals as compared with the French, but in the North of Scotland the French *flamboyant* style came in, of which there were many examples, especially in Linlithgow and Aberdeen. Up to the time of Edward I. the Scotch followed the English both in ecclesiastical and other matters; but then they went over to the French not only politically but in art matters. Too much praise could not be given to what had been done at South Kensington under the admirable administration of Mr. Sparkes.

The CHAIRMAN, in proposing a vote of thanks to Sir J. D. Linton, said he should like to refer, in connection with the Art Guilds, to what was going on in Paris under the name of *chambres syndicales*. There was an association there between the employers, foremen, and apprentices, and many large employers would spend several evenings a week in presiding over lectures of a practical kind given by the foremen, and specially addressed to the apprentices. He had always thought that this was an institution which might well be copied in this country. He did not depreciate the English workman, nor was it for him to say anything about the want of appreciation on the part of the public in art matters. It was quite sufficient to refer to the large number of visitors at South Kensington and Bethnal-green, to show the appreciation on the part of the public of the treasures

there collected. He wished they had a better outside, but the inside contained a magnificent collection unrivalled in the world, and worth above £2,000,000 sterling. He had heard even the President of the Royal Academy say that he had nowhere seen a finer or more magnificent collection than that brought together at South Kensington. And the objects were not all kept for the people of London, but some 30,000 objects were circulated throughout the kingdom. They could not bring the workmen to London, but they sent the objects to the workmen, and anyone who knew the excitement there was when those yearly changes took place from the South Kensington art stores, would feel how deeply appreciative the British workman was when he had an opportunity of seeing these things. He should like to remind the gentlemen who took part in the Liverpool Congress of the inscription over L'Ecole des Beaux Arts in Paris, "La critique est aisée, mais l'art est difficile." They had reason to be proud of what had been done in this country, and he saw no reason to despair on account of anything which had been said at Liverpool. He desired to thank Sir James Linton very warmly for his admirable address, which he had no doubt would have a great effect when it came to be read. Above all, he admired the practical suggestion with regard to guilds for the working-man, where he might listen to his employer or foreman, and learn what ought to be done to improve his manufacture. When a large deputation of practical carriage builders and other working-men — sent through the instrumentality of that Society — came over to Paris in 1878, to see the Exhibition, he had the honour and privilege, on behalf of the Prince of Wales, of receiving them, and endeavouring, with the aid of his staff, to make their week's visit useful. What he admired more than anything was that, instead of spending their evenings on the boulevards, or in amusement, they availed themselves of the clubhouse placed at their disposal, and spent their evenings in writing up their notes. He was proud of English working-men, and felt sure that if the practical side of these really professional guilds were carried out, we should very soon be able not only to maintain our position but even to make an advance on our French and German friends who were trying to take the bread out of our mouths. Give the British working-man fair play, and a little encouragement, and immense good would be done not only to him but to the whole country. South Kensington had lived on abuse for so many years that it was very pleasant to hear that it was appreciated by practical men, as had been stated that evening. He concluded by proposing a vote of thanks to Sir James Linton, which was carried unanimously.

Sir J. D. LINTON, in reply, said he agreed with a great many of the remarks which had been made. His paper, being on so large a subject, was necessarily very imperfect, and he had only slightly sketched in outline a scheme for guilds for art-workmen, his object being to get as near as possible to some practical solution; and he should be very glad if this were the result of his paper. Combination was always more powerful in its effects than the endeavours of separate individuals, and the great evil at present was want of organisation. If some body could be organised which would give them more power over the resources of the country, all would benefit in their individual crafts. He had no desire to elevate the Englishman above his neighbours, but he did venture to suggest that he was their equal, and he quite agreed with Mr. Robins that there was a distinctive character in English work which belonged solely to this country.

SEVENTH ORDINARY MEETING.

Wednesday, January 23rd, 1889; WILLIAM HENRY PREECE, F.R.S., in the chair.

The following candidates were proposed for election as members of the Society:—

Canning, Francis Lennox, Box 153, Johannesburg, Transvaal, South Africa.
Elliot, Hon. George F. S., 2, Pont-street, S.W.
Fenning, Rev. William Dunkin, Haileybury College, Hertford.
Johnston, Henry Augustus, 6, Drapers'-gardens, E.C.
Lishman, George, Tindale-crescent, Bishop Auckland.

The following candidates were balloted for and duly elected members of the Society:—

Beattie, William, 15, Holden-terrace, Pimlico, S.W
Dobson, James E., 42, Old Broad-street, E.C.
Evill, John Percy, 26, Collingham-gardens, S.W.
Gonzalez, Enrique, 128, Sutherland-avenue, W.
Kent, William James, Johannesburg, South African Republic.
O'Malley, Thomas George, care of Dr. Holmes, 101, Leadenhall-street, E.C.
Palmer, Frederick Danby, Great Yarmouth.
Peyton, Edward George, 20, Maxilla-gardens, W.
Webster, Thomas, M.A., Temple-lodge, Queen street, Hammersmith, W.

The paper read was—

ELECTRIC METERS FOR CENTRAL STATIONS.

By PROF. GEORGE FORBES, F.R.S.

There is no department of electric engineering which has interested me and occupied my thought more than that of central station work, and the distribution of electricity from these centres throughout a town for the production of light and power.

It was before this Society that I had the honour of classifying and developing the systems of distribution at the disposal of the engineer.* The position in which we now find ourselves is that, for extremely concentrated areas, a direct supply with continuous current dynamos, sometimes assisted by secondary batteries, and working on the three-wire system, is the most successful and the most remunerative; but for extensive areas the use of high-tension alternating currents in our mains, reduced in the houses by means of induction apparatus, is the most economical and flexible. This is the system which was first published and used by Gaulard and Gibbs. To take examples in the City of London. While we recommend the adoption of high-tension alternating currents by a company which is preparing to supply the whole of London with electric light, yet I felt that for the concentrated area bounded by Pall-mall, the Green-park, Piccadilly and the Haymarket, it was far best to recommend the low-tension three-wire system; and we may look forward to seeing that central station one of the most satisfactory in the world from every point of view. This is owing to its concentrated area, and the large consumption of light in the district.

It always seemed that the success of such central stations depends largely on the working out of details in the arrangements; details in the mechanical parts, details in the electrical parts, and I have seldom visited any such stations without seeing new points of detail, and learning new facts about the causes which lead to success and failure.

In order that we may make as few mistakes as possible in our central station work, one must try to learn as much as possible from countries which have made a greater start than England. Thus I was led to visit the stations established on various systems in the United States; and lately I have done the same thing with respect to the most important of the central stations in Europe.

Both in Europe and America there is one maxim which I find is conclusively established. This is, that the best paying stations are those in which the electricity is charged for by meter, and not at so much per lamp per annum. Both these systems are in use, but companies who have used both give their undivided testimony in favour of charging by meter.

I propose to deal with this important point of detail to-night, and to tell you something about the working of different types of meters in the United States as well as in Europe.

Now first let us settle the question what it is we want to measure. Both with gas and with electricity, if the company supplies burners or lamps it would be most desirable to measure the light given off. But this plan is not likely to be adopted in England. The private consumers generally supply the burners or the lamps. Hence what we come to is that we want to measure the gas or the electricity consumed. We want to measure its light-giving power. To do this we must know the quantity consumed and its quality. With gas, the latter is impossible to measure in the meter. We can only measure the quantity of gas consumed. We cannot measure its pressure nor its purity, nor the quantity of air or sulphur combined or mixed with it. These points are left to inspectors to determine, who shall insist upon a standard being maintained.

With electricity it is different. When we have measured the quantity consumed, there is only one quality which can exist, and that is its pressure. If, then, our meters measure the quantity consumed, and inspectors keep watch to see that the pressure is always maintained constant, the consumer's interests are amply looked after.

Now it has been suggested that we really ought to measure not the quantity of electric current which is consumed but the quantity of energy. Now the energy is the product of the quantity by the pressure, and could easily be measured if desired. There would be no object, however, in doing this. A deficiency of pressure is certainly undesirable, because the lamps burn less brightly, and the customer should be charged less. But, on the other hand, an excess of pressure is equally objectionable, because it injures the lamps, and it would not be fair to charge the customer more for the quantity he uses under these conditions. The only fair way is to do as with gas, *i.e.*, to measure the quantity used and guarantee the quality, *i.e.*, the constancy of pressure. This should never vary more than 4 or 5 per cent. at the most. For perfect lighting a variation of 2 or 3 per cent. only can be allowed.

I intend to direct your attention to various kinds of meters which have been put into actual practice, but before doing so it will be well to point out some of the *desiderata* in a perfect electric meter. I will deal with these in order.

1. *Accuracy.*—The meter must be at least as

* Cantor Lectures, 1885.

accurate as an ordinary gas-meter. In fact, that standard is rather low for modern requirements. The question of accuracy is two-fold. First, the readings of the meter must be accordant for all rates of supplying electricity within its range, and secondly, the indications of different meters must be consistent. This latter point is largely one of manufacture, so that it must be easy to manufacture the instruments in large quantities, all exactly similar.

2. *Range.*—It is desirable that the meter should be capable of working accurately over a large range of current strength. It would undoubtedly be desirable that the meters, made for the largest currents which can be used on a circuit, should also be capable of indicating correctly when only one lamp is in circuit. So far as I am aware, no electric meter has been invented fulfilling this requirement. It has often been proposed, with circuits of very many lamps, to have two meters—one for small currents, and the other for large ones—and to switch in the latter automatically when the current exceeds a certain amount. Any such arrangement, which involves an occasional use of a contact-breaker, is objectionable, owing to the sparking, and consequent deterioration of the contact. A far better plan, in the existing state of things, is to wire the houses in separate circuits of 20, 40, 60, or 100 lamps, according to the effective range of the meter adopted.

3. *Consumption of Energy.*—Energy must not be consumed by the meter to such an extent as to diminish injuriously the voltage supplied to the lamps. The wiring of a house diminishes the voltage at the maximum about 2 per cent., according to present practice. A meter ought not to increase this loss by more than ½ per cent.

4. *Simplicity.*—The meter should be simple to construct, and not liable to get out of order. Extreme delicacy in moving parts is to be avoided when possible.

5. *Durability.*—It is essential that no parts of the apparatus are liable to wear out rapidly.

6. *Attention.*—Other things being equal, that meter is the best which requires least attention. Any winding up of clockwork is objectionable, and the necessity of removing the meter or part of it from the consumer's premises should be avoided.

7. *Registration.*—The meter should register in a clear manner, so that the consumer can read it at any time and check its accuracy. A system of geared wheels with indexes and pointers, like a gas meter, is very convenient.

8. *Testing.*—A point of some practical value is that it should be an easy matter to test the meter, and that the operation should not occupy much time.

9. *Cheating.*—With some meters the process of cheating is easier than with others. The possibility of short-circuiting the meter is common to all, and can be obviated. Some meters can be retarded by placing a magnet near them; others by heating them, others by putting them out of level. This last can be prevented by securely fixing the meter to a wall or floor.

10. *Economy.*—A meter will not be practical if it entails a large rental, and so adds much to the quarterly bill.

11. *Freezing.*—A meter which contains a liquid which can freeze is objectionable in any but warm countries, since a lamp or other resistance must then be put inside it to keep it warm, and this is a constant source of waste of energy.

12. *Alternating and Continuous Currents.*—Some meters are only usable with continuous, others with alternating, currents. A meter which reads with equal accuracy for both kinds has a double value. Many stations supply both classes of currents, and it is less inconvenient to deal with only one type of meter.

13. *Number of Alternations.*—Meters for alternating currents ought to indicate with equal accuracy, whatever be the number of alternations per second. Otherwise irregularities will occur, and also the supplier of electricity can cheat by altering the number when under test, and also when at actual work.

14. *Contact-breaking.*—No contact-breaker of any electric circuit should be allowed in a meter, because such contacts deteriorate with use.

15. *Mailing.*—The meters should be so substantial that they can be sent by rail without accident.

No one meter fulfils all these requirements perfectly. But all the meters which I am going to describe fulfil many of them, as they all have done good practical work on central stations.

In all the meters which I have to describe the registration is effected either by moving mechanical parts or by electrolytic decomposition. In most of the mechanical meters a certain dynamical principle has been employed to guide the inventors to an accurate instrument for different strengths of current. I will now explain this. In the class of meters I

allude to the electric current sets some mechanism in movement. Now we all know that generally the work done by a current in a given time varies as the square of the current. Thus the electrical force tending to drive the mechanism is proportional to the square of the current. Such mechanism would increase its speed indefinitely under the influence of such a force if there were no friction opposing the increase of speed. In the meters I allude to the friction of the air or of a fluid is opposed to the driving force of the electric current. This resistance increases as the square of the velocity. The electric force goes on increasing the speed of the mechanism until the opposing friction equals the driving force of the electric current. But the friction varies as the square of the velocity, and the driving force varies as the square of the current. Hence in all cases where the mechanism acquires uniform speed, the square of the velocity is proportional to the square of the current; in other words, the velocity varies as the current. Now, the indications of such an instrument as shown by an index gives the number of revolutions of the mechanism in the period of testing, which means the velocity multiplied by the time, and this is proportional to the electric current multiplied by the time. Hence the index marks the total number of ampère hours, or the total number of Board of Trade units which have passed through the instrument.

Edison Meter.—In describing the different meters, I will begin with the Edison meter, not only because it was the first to be used, but also because it has done a larger amount of useful work in central stations than any other meter. In its original form, as shown in the Paris Electrical Exhibition in 1881, it consisted of two copper plates suspended from the two ends of a balanced beam in a solution of sulphate of copper. A continuous current passing through from one plate to the other decomposed one plate and deposited copper on the other. This one eventually got heavy enough to tip over the balanced beam. This mechanical action had two effects, (1) it registered a unit on the counting mechanism, and (2) it reversed the direction of the current; and now the lighter plate received the copper deposit, and so the process went on continuously. It was not possible to pass the whole current in this way through the solution, because the resistance would be too great. Hence the depositing cell was put as a shunt on the main current. Several objections to this type soon became apparent in practice. (1) When the temperature of the air was high, the resistance of the solution diminished, while the resistance of the alternative metal path increased. Hence with high temperatures a greater proportion of the total current went through the meter. (2) It was soon found that a make and break, as necessitated by the reversals in the direction of the current, led to endless trouble, and the ingenious method of counting had to be abandoned. In the improved meter, zinc is the metal employed, and sulphate of zinc the solution. The current always goes in one direction. Fresh plates are inserted as they wear away. To determine the consumption of electricity, the meter is carried away and the loss of zinc in the positive plate is weighed, and the consumer charged for a proportionate number of units of electric current; $\frac{1}{1000}$th of the total current passes through the zinc solution. In series with this solution is placed a copper resistance, so arranged that with a rise of temperature the fall in resistance of the solution equals the rise in resistance of the copper, the alternative path being of German silver. Thus between 4° and 34° C. the same fraction of the current passes through the solution. To prevent freezing, an incandescent lamp is always kept burning in the case containing the meter during the months that freezing is possible.

The range within which the meter is said to be accurate within 3 per cent. is from 5-fold to 10-fold, *i.e.*, if one ampère is the lowest current for which it is accurate, then 5 or 10 ampères is the maximum current for which it is accurate.

Now, you may say that this is not exactly the kind of meter we require, because customers cannot check the weighings, and are absolutely dependent on the good faith of the company supplying the electricity. It has also been argued that the shunt arrangement cannot be perfect with varying temperatures. Well, I can only say that the meter in practice is found to do good work. I agree entirely with what Mr. Edison said to me about it. He said:—"It is not an ideal meter, but it is simple and effective, and gives general satisfaction wherever it is used." I endorse this opinion. But the managers of central stations where it is used have given me higher estimates still of its value. They say that customers are all quite content with the manner of reading it. As to accuracy, many customers have kept accurate tally of the lamp hours which they have consumed, and

compared it with the charges by meter, and have often come within 2 or 3 per cent. At the splendid central station at Milan, which I lately visited, this meter is in constant use, and is much appreciated by the company. They say that the expenses of maintaining the meter department are not large when the whole thing is well organised. The total number of ampère hours sent out from the station, as measured by the ampère meters, agrees with the meter accounts within 3 per cent. This station, which I have carefully inspected, is an admirably conducted one, and embraces three systems, the Edison low tension, the alternating high tension, and the Thomson-Houston arc lamp systems.

Ferranti Meter.—The next meter which I wish to describe is that of Mr. Ferranti. It is one so beautifully simple in its principle as to please at first sight. It is founded on the principle that when an electric current passes through a fluid which is placed in a magnetised space, the fluid tends to move in a direction perpendicular to the current and to the magnetic action. Two magnetic poles of circular form are placed one above the other, one being a north pole, the other a south pole. Between these two is a circular insulated trough containing mercury. The current enters the mercury at the centre of the trough, and the outer rim of the trough forms the other electric terminal where the current goes out.

The original instruments were intended for currents continuous in direction, and the magnets were excited by the electric current to a moderate amount, so that the magnetism was proportional to the current. Thus the moving force was proportional to the square of the current, and the friction of the mercury being approximately as the square of the velocity, the indications of the instrument would be accurate. Of course the law I have spoken of is only true as a sort of approximation. The friction of the indicating mechanism follows a different law, and affects the result. The number of rotations made by the mercury is indicated by the rotation of a float of special construction, resting on the mercury, connected by a spindle, with a train of wheelwork which indicates the total number of revolutions. The meter has also been adapted for alternating currents, and is rendered more delicate by having an additional shunt winding of very high resistance. This circuit is put in multiple arc with the lamps on the two mains of the house supply. The friction of the wheel train is reduced to a minimum by employing the finest and lightest mechanism which can possibly be constructed. I am sorry to say that Mr. Ferranti has not been able to furnish me with any tests or specimens of his alternating current meter, as he is even now introducing some improvements. I am told the range is about 50-fold, and that it is very accurate. I may mention, in praise of Mr. Ferranti's ingenuity, that both Mr. Edison and Mr. Weston, in America, two of the most prolific inventors, tried to work out a similar instrument and found it ineffective. The chief difficulty was one which, until Mr. Ferranti attacked the problem, has been taken as a universal fact, viz., that mercury is unsuited for a permanent contact. They found that the mercury got covered with a film or powder which interfered with its free movement.

Aron's Meter.—I now come to a very interesting type of meter, the principle of which was first suggested in this country by Professors Ayrton and Perry, and which has been made a practical instrument by Mr. Aron, in Germany. I have lately visited the central stations of Berlin, the largest existing on the Continent. These stations are the best equipped in the way of boilers, engines, dynamos, and accessories of any low-tension system I have ever seen. There is this defect however, that they have hitherto used a distributing system with two instead of three wires. This fault will be remedied in the future. They supply at present current sufficient for a maximum supply of 26,000 incandescent lamps of 16-candle power. And here let me protest against the practice, beginning in this country, of taking an 8-candle power lamp as the normal one. Everyone is dissatisfied with the low candle-power prevalent in London, and, as a general rule, 16-candle power lamps have been found in actual experience in hundreds of central stations to be the most suitable. The stations also light the Unter den Linden with 108 arc lamps of 15 ampères, and the Leipziger Strasse with 36 arc lamps. The former is the finest piece of street lighting ever accomplished.

All the incandescent lamps are charged for by meter, and the Aron meter is always used. Originally it consisted of an ordinary clock, with a permanent magnet for the bob of the pendulum; below this a coil of wire is fixed with its axis vertical. The current to be measured passes through this and repels the magnetic pole, thus diminishing the influence of gravity on the pendulum, and causing the clock to

lose time. The loss of time in any period, as compared with a good, uninfluenced clock, shows the number of units of electricity which have passed through the instrument. It takes a long time to test such an instrument over its whole range, and I have not been able to obtain any tests. The chief inconvenience of the instrument in its old form was that a clock could not be depended upon for accuracy more than about half a minute a week. One minute a week would be the smallest registerable quantity. Suppose this means one lamp hour, then the maximum loss of the clock in the week being 12 hours, the instrument could not register more than $12 \times 60 = 720$ lamp hours per week. Another inconvenience was having to wind up so many clocks every week. The former defect has been got over by mounting two clocks on the same framework, one in its normal condition, the other governed by the current. The two trains of wheels are connected by a differential gear with a third train of wheels with dials and pointers like a gas-meter. This increases the range of the instrument, so as to be practical. Of course, this improvement diminishes the accuracy of the instrument (1) by introducing more work for the clocks to do, and (2) by having to deal with the ordinary errors of two clocks, and every clockmaker knows that two pendulum clocks, mounted on the same frame, affect each other's going, and introduce errors. The principle of this meter is very beautiful, and in the Berlin central stations the authorities speak in very high terms of its value. Complaints from customers do come in, but in these cases the meters are tested, and found to work quite well. Its range is greater than for any other meter, being about 100-fold, I believe.

This meter has been altered, to adapt it for registering alternating currents, by replacing the permanent magnets by coils, or electro-magnets. In the central station at Rome, which is in many points the finest and best-designed station for alternating currents which I have yet seen, it is intended to test these meters. But I can say nothing about their accuracy. I will only point out that in this case the retarding influence varies as the square of the current, whereas, with the permanent magnet, it varies as the current. This does not lead us to hope for the same satisfaction as is afforded by the type for continuous currents.

Lowrie-Hall Meter.—I will now say a few words about a meter specially designed for alternating currents, which resembles the Edison meter more than any other. This is the Lowrie-Hall meter. A battery—preferably a secondary battery—is placed on the secondary circuit of a transformer. An electrolytic cell is also placed in the circuit. Now there is no complete circuit through the battery and electrolytic cell except when lamps are in circuit. and it is only then that electro-chemical action can take place. The alternating current does not transfer metal from one plate to another. The whole effect in this way is produced by the battery, which acts as if the alternating current did not exist. The continuous current thus flowing is proportional to the conductivity of the circuit, *i.e.*, to the number of lamps at work. Thus the total number of lamp hours, or Board of Trade units, is measured by the quantity of metal lost by one plate or gained by the other. This is an extremely novel and ingenious idea. One is inclined to ask how long the battery will stand the alternating current, and whether there is much trouble in charging and replacing the secondary batteries. I am informed that these meters have been successfully at work at Eastbourne for more than a year.

Schallenberger Meter.—A very practical form of meter has lately been brought out by Mr. Schallenberger, electrician to the Westinghouse Company at Pittsburgh, an extremely ingenious and accomplished electrician. It also is intended for use only with alternating currents. This is not the place to go into a scientific examination of the theory of its action. I will try to explain it in popular language. A circular iron disc is placed on a vertical arbor connected with the indicating mechanism, and also carrying a fan to introduce resistance to movement by air friction. The iron disc rotates very freely. Two diameters of this disc are chosen, inclined to each other at 45°. A coil of wire or copper ribbon fixed to the casing is coiled round each of these diameters. One of these coils is connected with one of the wires going to the lamps, and consequently has an alternating current flowing through it. The other coil is closed on itself, and has induced currents attaining their maxima a quarter of a period later than the main current, *i.e.*, when the main current is zero. Now consider the instant when the main current is a maximum. It magnetises the iron disc, and a quarter of a period later the induced current, acting at an angle of 45°, tends to turn the disc in a certain direction. When

the main current is reversed the magnetism is reversed, and the secondary current is also reversed, and hence rotation in the same direction ensues. Thus we have continuous rotation of the iron disc when an alternating current is flowing through the main coil. It is found that for a 15-fold range the number of revolutions of the disc indicate the total number of lamp-hours or Board of Trade units, which have passed. This is a very convenient type of meter. It does not require great delicacy of construction, and is not liable to get out of order. The objection to it is that its indications vary with the speed of reversals of the alternating current, and our best governors are not perfect, and our most reliable suppliers of electricity would be tempted to alter its indications by increasing the speed of the engines a little. But the meter remains a beautiful practical instrument, which is doing splendid work in the United States. Mr. Schallenberger promised to send me one of these meters, but I am sorry to say it has not yet arrived.

Forbes's Windmill Meter.—Some years ago, when I first realised the value of the invention of Messrs. Gaulard and Gibbs, for distributing high-tension currents in the mains and delivering it as low tension in the houses, I felt that one difficulty in the way of adopting it was the want of a meter for alternating currents. Such a thing did not exist, and I felt certain that the public would never be satisfied with a meter whose indications depended on the speed of reversals. It therefore seemed to me that the heating quality of the currents was the only one which would succeed, and would be equally applicable to continuous and alternating currents. I was fortunate enough to have the kind assistance of Mr. A. Stroh for perfecting the details, and eventually the windmill meter was completed, in which the heat generated in a resistance sets up convection currents in the air, which work a kind of windmill. Here the force is proportional to the square of the current, and the opposing resistance is air friction, which varies as the square of the velocity, so that it was natural to expect that the indications would be accurate, and this was found to be the case.

The windmill which I use is made of a horizontal mica disc, with mica vanes round the edge, inclined at 45°, attached to it by small pieces of pith. It has a hole in the centre, in which is fitted a thin paper cone, which has at its apex an aluminium cone, supporting a steel pinion with a ruby cup in its centre. This cup rests on a needle point, and the pinion works into the train of wheels which does the counting.

When this meter was perfected, it seemed that the English demand was not great, and it was best to modify it to suit the American market. I went to America to find out exactly what was wanted, and altered the instrument accordingly. The chief objection raised to it was the difficulty of mailing it, and a fear that it was too delicate. Consequently I strengthened some of the parts, reduced the sharpness of the needle point, and provided a metallic case in place of a glass shade. A considerable number have been sent across the Atlantic in both directions by the ordinary channels without any injury. On arrival all that has to be done is to release a spring, so as to free the windmill and let it play upon the needle point. The electric resistance of the conductor had also been objected to. This I was able to correct by altering the form of the conductor in which the heat is produced. Its resistance is now $\frac{1}{100}$th of an ohm, and Mr. Schallenberger, after testing, at Pittsburgh, a batch which were sent direct from the workshop, without any adjustment, wrote to me, saying that they are quite accurate, and that the fall of voltage, due to resistance, is quite low enough, and that they were put to work on the regular commercial circuits. Mr. Westinghouse has acquired the rights for America, and is now manufacturing them at Pittsburgh. It is the only meter which he supplies for motors and continuous currents, and it also works equally well with alternating currents, of any speed of alternation. For alternating currents he has hitherto used the Schallenberger meter, The range of my meter in the American pattern is about 12 to 15-fold, about the same as the Schallenberger meter. When I use more delicate wheel-work, the range is greater.

I need hardly say that the perfecting of such a meter has led to innumerable experiments. Trials have also been made of a variety of other means of utilising the heat. I would not be doing my audience justice if I did not show them one other type which I have constructed, which is very simple and effective, but which has one slight defect, viz., that it is not easy to manufacture in numbers all exactly alike. It consists of a wire conductor covered with cotton, which absorbs alcohol from a reservoir. The electric current being passed through the wire heats it and evaporates the liquid, which is condensed in a

tube, where it is measured. This quantity is an exact measure of the quantity of electricity which has passed through. This instrument has not been used on commercial circuits.

Since the beginning of September, 1887, when I first exhibited the mill-wheel meter, an enormous number of patents for meters have been taken out, but I think I have described all that have as yet proved themselves to be of practical value. Each of the meters I have described has its merits, and all are doing good work in central station distribution.

DISCUSSION.

Mr. R. E. CROMPTON said he had had some practical experience with the Aron meter, but it had been principally through a third party—Mr. Miller, who could have spoken with much more authority as to its performance. They had at first enormous trouble with it, but were eventually successful, and it was through Mr. Miller that many of the improvements had been made. They commenced with another form of meter, which was not satisfactory, and which was now superseded by the Aron meter. In its original form the clock was started by a detent when the current was turned on, but that gave endless trouble, as the clock did not always start, and consequently they lost, not only a record of the rate between the visits of the attendant, but actually lost all record, as the meter registered back, which was a very serious affair. Mr. Miller made some suggestions, which resulted in the simple clock which was now employed, and ran for 30 days, and since then many of the difficulties had been removed. He had recently spent some time in Berlin, and found that they were thoroughly satisfied with that meter, but he should say that it only registered the current supplied to incandescent lamps, whereas the success of the Berlin station depended on arc lamps, which formed about three-fifths of the whole, and they were charged mostly by contract. At Kensington they had never sold current otherwise than by meter, in which he believed they stood alone. At Liverpool, however, there was a central station which worked largely by meter, and by one which had not been mentioned, viz., the Chamberlain and Hookham, which, he was told, had been working there for some weeks, and proved as accurate as the Aron, and was in some points superior, though he did not know the particulars. He could endorse what had been said about the use of the Edison meter in America. He believed no meter had been more aspersed, but at the same time it had done infinitely more real work than any other, and it had been very unwisely neglected in this country. At the time Mr. Ferranti was bringing out his meter, Mr. Kapp and himself were experimenting on exactly similar lines, but Mr. Ferranti was a few days earlier in applying for his patent. With regard to lamps, if Professor Forbes had had practical experience in lighting private houses, he thought he would advocate 8-candle power lamps, because we had to compete with gas, and keep down the annual bill. The greater part of the expense of lighting was incurred for passages, staircases, and so on, and for this purpose a unit a little over 8-candles answered extremely well. Every one who saw the so-called 16-candle lamps worked at the volts at which they were sent out by the Edison-Swan Company, admitted there was a great waste of light when used in such situations. These lamps originally yielded 18 candles, or more, but since the improvement in the manufacture of the lamps, they had been able to work them slightly in excess of what they were marked. Those marked 8 candles and 97 volts could be worked at 102, and yielded about 11 candles when new, and when quite old, the original 8. Customers who could buy the larger lamps if they liked, preferred the smaller ones, and more than three-fourths of those in use were the smaller unit. This was not so in shops, clubs, or hotels, where larger lamps were more satisfactory; but to make the electric light spread rapidly, and not frighten the people by the cost, the smaller lamps should be encouraged. He greatly admired the magnificence of the Berlin central station, but it was very costly, and he thought the same result could be obtained in England for very much less money.

Professor AYRTON, F.R.S., after paying a tribute to the modesty displayed in the paper, which he would endeavour to emulate, said he should like to break a lance with Professor Forbes on the old dispute as to whether electricity should be charged by quantity or by energy. It seemed to him that people were somewhat influenced by the meters they had to supply, and naturally liked people to pay for a thing the meter would measure rather than that the meter should measure the thing they ought to pay for. No doubt if it were possible to maintain a constant potential difference between the supply mains, the total quantity supplied in a given time was all that need be considered, but this constant difference of potential was not maintained. Professor Forbes admitted there was a $2\frac{1}{2}$ per cent. variation; but that amount of variation in the volts meant a very great difference in the amount of light, which was really what the customer thought about. He did not care about volts, watts, or anything else; he bought light, and wanted a meter to measure what he was paying for. A variation of $2\frac{1}{2}$ per cent. in volts—and it was more in practice—meant a considerable drop in the light, which was about proportional to the cube of the volts, minus a constant, as shown by the experiments made by Professor Perry and himself on several types of incandescent lamps some years ago. The other day he was in St. James's-hall, during an afternoon performance, when the light went down so much that the gas had to be turned on full. Supposing

you were paying by current, you would pay not much less than if the right voltage were maintained between the terminals, and if a few more lamps were turned on the total current would be the same, but the light obtained would be nothing near the same, so that during that half-hour the customer would be paying the full gas bill, and the full electric light bill as well. In fact, so far from employing a meter which took no notice of any variation in the volts, as was advocated by Professor Forbes, he was not sure but that the meter ought to take into account some higher power than the first of the volts, so that it would measure, perhaps, the integral of the product of the current into the square of the volts, seeing that the light fell so rapidly with the fall in the volts; but whether this was done or not, they certainly ought not, he thought, to be satisfied to neglect variations of even the first power of the volts on the indications of the meter. There was one point about the simplicity of testing which Professor Forbes had not referred to, which existed in retarded clock meters, but in no others. During the time you were not using the electricity you could check the accuracy of such a meter, because the clock, which was simply retarded when the current was supplied, was not retarded at all when there was no current passing, and you could therefore compare the going of the meter during the day with any respectable watch, and with which it ought to keep time. No one of the other meters could be tested in that way. A way Professor Perry and himself suggested some years ago of getting over the possibility of cheating in an ergmeter for measuring the product of the current into the volts, had a pendulum wound with wire, the wire round the pendulum being a shunt to the main circuit. By putting a magnet near the clock the consumer might prevent it being retarded so much, but it was proposed to occasionally reverse the current in the whole system, which could easily be arranged, and the result would be that anyone who tried to cheat by the use of a magnet would be as likely to increase his bill as to lower it. He agreed in the objection which had been raised to contacts in meters, but there was one meter patented some years ago by his colleague and himself which was not open to the same objection, though it had two contacts. It was a motor, the field magnets of which were wound with thick wire, and there was a continuous circuit through them—no make or break at all. The rotating armature was wound with very fine wire of high resistance, and there were two brushes to lead the shunt current through the armature, and any changes in the resistance of the contact of these brushes made very little difference in the total resistance of the shunt circuit. There were no brushes in the direct circuit, and any slight amount of dirt which in time accumulated under the brushes in the shunt circuit introduced very little error. He ought to mention in passing that the ergmeter had no defect, in that it measured what the customer ought to pay for. If the supplier could keep a constant difference of potential between the terminals, then the ergmeter became a coulomb meter, but if the supply were variable the ergmeter checked the supplier if he did what he ought not to. He thought Professor Forbes must be in error in speaking of fluid friction being proportional to the square of the velocity; with small velocities the retardation was not proportional to the square but to the first power of the velocity; with a velocity such as existed in the beautiful instruments on the table, the vanes were not moving much faster than the needle in a ballistic galvanometer, and the damping correction of that instrument was, as was well known, on the principle that the retardation did not vary with the square of the velocity. Indeed, their own motor ergmeter, in which fluid friction was used, and which was patented in 1882, was based on the principle that the friction was proportional to the first power of the velocity. There they wanted to measure the time integral of the product of the current passing through the field magnet, and the current passing through the armature, which integral was directly proportional to the energy. The force-causing motion was proportional to the product of the two currents, and if it were assumed that for slow velocities fluid friction was proportional to the velocity, the distance travelled through by the armature would be proportional to the watt seconds, or, in other words, to the total energy supplied. If the retardation were proportional to the square of the velocity, the meter would not have worked satisfactorily. While on the subject of fluid friction, he would allude to one defect with all these moto meters which had prevented them improving and introducing their own motor ergmeter. You wanted simpler fluid friction, not solid friction. You must not have the friction of mechanism, and therefore it was necessary to reduce the dials and recording mechanism to such very minute dimensions, and to make them so delicate that great difficulty was introduced. That was the great difficulty with the Ferranti meter; if he had no recording mechanism his meter would have been perfect; but the friction introduced by the dial mechanism was a great difficulty, and he understood that though Mr. Ferranti had many thousand lamps at work where the current was measured by these meters, he was not yet satisfied with them, and was sending to America for machinery to make more delicate dial mechanism. The retarded clock-meter had no such defect, as the mechanism was not driven by the current. In one sense it was a defect to have to introduce another motive power, but by so doing you got over the difficulty he had mentioned. The friction of the mechanism introduced no more inaccuracy than was to be found in a good chronometer. With a motor meter it was absolutely necessary to reduce the dial mechanism to the smallest possible dimensions. His colleague and himself owed a debt of gratitude to Dr. Aron for the way in which he had carried out the principle they had put forward, and, as his

agent had wisely commercially acknowledged their claims to priority, there was perfect accord. He was a little surprised to hear of the success of the Lowrie-Hall meter, which was based on the assumption that the alternate current, when passing through a voltameter or an electrolytic cell, produced no decomposition, but this had been found, from the experiments made by his students, an extremely difficult condition to arrive at. It meant that if you sent an alternate current through a voltameter no gas would be produced, but, in fact, you could easily get a considerable amount produced, and you could get copper deposited with a current making many thousand alternations per minute. He was much surprised, and at the same time much pleased, to hear that this difficulty had been successfully surmounted. At the end of the paper Professor Forbes had briefly described a meter which gave its indications by means of the evaporation of alcohol. A meter on the same principle was made at the beginning of last year, by Mrs. Ayrton, mainly by her own experiments at home, though tests upon it had been subsequently made by her at the Central Institution. In that case, water was evaporated by the passage of the current; the water fell through a tube, and, according to her design, worked a recording mechanism, and was finally carried back to the reservoir to be re-evaporated. He had nothing to do with the invention himself, and had, in fact, rather discouraged it, in consequence of the difficulties of such an investigation. He, therefore, now penitently desired to place her meter on record.

Mr. SHOOLBRED, referring to what Professor Forbes had said of the unsatisfactory system of measuring the nominal output of an installation, said it ought not to be measured at all by quoting the number of lamps, either 8 or 16 candle, because persons were asking every day for 30 or 100-candle lamps, and even higher, not to speak of other uses for the electric current. It would be much better to speak of the relative value either in watts or ampères. He thought sufficient stress had hardly been laid on the importance of simplicity and durability in meters, especially bearing in mind the places in which they were likely to be put. Many of those to which reference had been made as having been tested were placed in central stations where they could be carefully attended to, but that would not be the case with those supplied to the public.

Mr. SMARTT said he was interested in introducing the light into a certain district, and he was anxious to ascertain the relative cost of gas, electricity, and oil; but it appeared to him that it would be an important element in considering the cost of the electric light to know what would be the cost of the meters. It was also of importance that they should be correct.

Professor FORBES, in reply, said he was very sorry Mr. Miller had not been present to give his practical experience, but he understood that at Berlin the single clock-meter was found more successful of the two types of Aron meter, and he was surprised to hear Mr. Crompton intimate that was not so at Kensington. He was very sorry there had been any meter which had been successfully employed in central stations which he had not described. He was aware that Messrs. Chamberlain and Hookham had devised one, but did not know it had been in practical work, and he should make it a point to learn more about it. Since Professor Ayrton had expressed a desire to break a lance with him on certain points, he should be quite willing to discuss the point in a few sentences. Professor Ayrton tried to reduce his proposition to an absurdity; and he would endeavour to do the same with what Professor Ayrton had said. It was intimated that those who made meters did not make them to satisfy the wants of the customer, but tried to make the wants of the customer meet the performance of the meter. The customer wanted to measure the quantity of light, which was proportional to the cube of the volts, and there was no doubt about it, according to Professor Ayrton, the erg was the proper thing to measure, since this is what his meter measures — whilst he (Professor Forbes) said the coulomb was the thing to measure—the total quantity of current passing through. He said no. When the lamps were burning down very low, it was a great shame the customer should be charged almost as much as when they were burning brightly. Now, supposing he were supplied by meter, and charged by ergs, by the volts multiplied by ampères. Those who supplied the current would want to send a greater pressure through the lamps than the customer wanted, and so break them down, and the customer then would not only be injured by having his lamp destroyed, but insulted by being asked to pay more in his meter account for this. He thanked Professor Ayrton for his information about another inventor who had been working on the same line as himself; a great many had tried evaporation, but he had not seen one which made the results proportional to the current going through the meter. With regard to the cost of meters, he had very little information. In America the idea was that they ought to cost about £1 to manufacture, and sell at about double that price, but he did not think they would come down to that in this country. They would probably sell for from £4 or £5 up to £18 or £20.

Mr. HOWARD SWAN said Mr. Crompton's remarks had been misunderstood by Professor Forbes. The same form of Aron meter was in use at Kensington as had been found most successful in Berlin.

The CHAIRMAN, in proposing a vote of thanks to Professor Forbes, said it was quite true that he felt it extremely depressing to walk through the dull and dismal streets of London after coming from New York, which was brilliantly lighted by electricity; but on hearing such papers

as this, he felt that there was a possibility of that depression being removed. He himself lived in an atmosphere of electricity, his own house being lit by it, and whenever he went to see his friends he could only pity them for living under the depressing influence of gas; and he hoped the day was not far distant when others would be as comfortable as himself. He believed we were on the eve of a boom in electricity. Only yesterday the Commissioners of Sewers of the City of London decided on issuing a specification and inviting tenders for lighting the City, and it was to be hoped that before the end of the year, Fleet-street, Ludgate-hill, and Cheapside would even surpass the famous Unter den Linden. With regard to 16- or 8-candle lamps, he agreed with Mr. Crompton that when Professor Forbes had had more practical experience of the fitting up of private houses, he would come to the same conclusion as Mr. Crompton and others, that the proper candle power to use in houses was 8 or 10. In a large hall it would be absurd to use such lamps, but there really ought to be a new system introduced, as Mr. Shoolbred had said, of speaking of lamps not by candle power, but of so many watts. The standard lamp in his practice was one of 50 watts. If people in the Colonies or abroad sent home indents for an electric installation for so many thousand lamps, no one would know what they wanted; but if they sent for so many lamps of so many watts, they would know exactly what to send, the proper dynamo to give the current, and the batteries required to maintain it. Throughout the Post-office they commenced with 16-candle lamps, but found that 10-candle gave all the light required. The real question was not so much the power of the lamp as the proper distribution of the light. When you had decided on the amount of light required to read, or write, or to do any particular work, it was easy to calculate whether the lamp should consume 30, 50, or 100 watts, because that simply depended on the position in which it was placed.

The vote of thanks was carried unanimously, and the meeting was adjourned.

Mr. A. W. Swan writes:—

Professor Forbes has given us an admirable *resumé* of the present state of knowledge of electric current meters, or at least such of them as have come into practical use. If he had extended his view so far as to embrace experimental meters, it would have been necessary for him to have given—not a lecture, but a course of lectures. The number of meters to be described would have been increased tenfold. Of this number, some that I have made would, perhaps, have been thought worthy to come into the record. His lecture occurs at an opportune moment, when large projects are afoot for the distribution of electric current from central stations, and when, therefore, electric meters are an imperative necessity.

Nothing more strikingly illustrates the rapid progress made during the last seven years in the use of electricity, especially in connection with lighting, than the fact that at the beginning of this period there was no such thing as an electric meter, and now there are thousands of electric meters in actual use.

I remember very well when the details of the Electric Lighting Act, of 1881, were under discussion amongst experts, the question whether electric current could be charged for by meter was asked by the Board of Trade, and it had then to be admitted that there was no instrument known that would measure electricity as a gas-meter measures gas. I ventured to express the opinion that although it could not be denied that that was the case, yet the principles upon which meters could be constructed were well known (the principle of electrolysis, as seen in the Daniel's battery and the voltameter, was the best known and most obviously applicable at the moment), and that considering how invariably under such circumstances supply followed closely on the heel of demand, I felt no doubt whatever that as soon as central stations were ready for the meters, the meters would be ready for them. This forecast has been fully verified by the fact; and from the exhibit we have had placed before us to-night, coupled with the indication afforded by the Patent-office of an extraordinary amount of inventive activity concentrated on this subject, it looks almost as if the demand was not merely about to be supplied, but supplied superabundantly. Meanwhile, although we have got several kinds of meters, all of them reflecting the highest credit on the ingenuity of the inventors, if I single out any one of these as especially deserving of mention for felicity of idea, and exquisite development of the idea, I should certainly have to mention the exceedingly beautiful meter of Professor Forbes.

I do not remember how many it possesses of the thirteen qualifications which Professor Forbes told us should be possessed by an ideal meter, but certainly in his they will count up to a goodly number. I believe I am right in thinking that it was the first of those meters which measure both continuous and alternating currents. How surprisingly the supposed disabilities of alternating currents have melted away in the presence of that all-solving sun—necessity. Now we have not only motor meters, but also electrolytic meters for alternating currents. Truly, "All precious things discovered late, to those who seek them issue forth;" and at last I suppose we shall have our ideal meter.

The things most lacking in the best of the meters shown to-night are want of range and want of simplicity. Range and simplicity were two of Professor Forbes's thirteen points. To put the first of these into figures, I should say that the range should be at least 1 to 100, instead of 1 to 15 or 20, the range of those meters which so far have the greatest number of the thirteen points. In respect of

simplicity, and consequently of cost, I think all the motor meters leave much to be desired.

The experimental meter which Professor Forbes showed us last, if he can conquer the difficulties of detail that stand in the way of its being made a practical instrument, as he has conquered the seemingly as great difficulties of detail in the case of his windmill meter, would, I think, score most of the thirteen points. Certainly it would have the very great merit of simplicity and wide range, and I earnestly hope that he will persist in the endeavour to perfect it.

Miscellaneous.

PREPARATION OF RAMIE FIBRE.

In a late number of the Kew Gardens *Bulletin of Miscellaneous Information* is a report on the series of trials of methods for preparing ramie fibre undertaken by the French Government, which was drawn up by Mr. D. Morris, Assistant-Director of Kew Gardens, who attended the trials on behalf of the India-office. The following particulars are taken from this report:—

"In the French *Journal Officiel* of the 13th of April last there appeared a ministerial order approving an international competition of methods (mechanical and chemical) for preparing the fibre of the ramie plant. The order was based on the fact that considerable interest was taken in the cultivation of the ramie plant in Algeria and French colonies generally, and that it was a matter of national importance to solve the problem of preparing ramie fibre so as to bring it within the reach of commercial enterprise.

"The competition was, in the first instance, fixed for the 15th August, but it was afterwards postponed to the 25th September, on account of the unfavourable season which had been experienced for the growth of the ramie plant intended to be used in the trials.

"*Importance of the Ramie Question.*—It is well known that the production of the fibre of ramie in commercial quantities, and in an economical and remunerative manner, has constituted one of the most important industrial problems of the present day. It has been keenly followed in nearly every part of the world; but the chief efforts hitherto made have been confined to India, to the West Indian Colonies, to the United States, and more recently to France and her colonies.

"The Government of India, nearly twenty years ago, was led to offer a reward of £5,000 for the best method for preparing ramie fibre, and presenting it in a suitable condition for textile purposes. It was led to this step by the conviction that the only obstacle to the development in India of an extensive trade in ramie fibre was the want of suitable means for decorticating the plant. This was the third time that ramie had become the subject of official action. The first effort for utilising this plant was in 1803, when Dr. Roxburgh started the question; the second was in 1840, when attention was directed to it by Colonel Jenkins. The offer of £5,000 in 1869 induced many competitors to enter their names, but it was found that no machine fully fulfilled the conditions laid down by the Government, and therefore the full prize was not awarded. Other unsuccessful attempts were subsequently made, and eventually the offer of £5,000 was withdrawn.

"Since that time many thousands of pounds have been spent on the ramie plant, and the aid has been invoked of both mechanical and chemical science to solve the problem connected with decorticating the fibre. Many processes have been brought forward from time to time, and it was claimed for each of them that they had fully realised the hopes of their inventors. But promising as some of these processes were, they do not appear to have been introduced into regular use, and only one or two have at all come into prominence.

"Naturally the earlier attempts to prepare ramie fibre had followed the methods already in use in preparing flax, hemp, and jute; but it was soon evident that as regards ramie these methods were useless. The fact that the fibre of the ramie is embedded in a gummy matter offered the greatest obstacle to the production of clean and bright threads suitable for the spinner.

"*Arrangements for Paris Trials.*—The *Concours International de la Ramie*, recently held at Paris, took place in one of the annexes of the proposed exhibition of 1889, on the Quai d'Orsay (Place de l'Alma). It was attended by representatives from all parts of the world.

"It was evident that the proceedings were watched with considerabie interest by inventors, no less than by persons directly interested in the cultivation of the ramie plant. Very complete arrangements had been made beforehand by the French Ministry of Agriculture. Steam power was provided, and a large supply of green stems (of the species *Boehmeria nivea*) had been grown in the neighbourhood of Paris ready for the trials. Dried stems had been obtained from Algiers, while to test the chemical processes a quantity of ramie ribbons were available, ready to be converted into filasse.

"The entries previously made at the Ministry of Agriculture included 19 machines and 10 (chemical) processes. On the morning of the trials only four machines and one chemical process were submitted to the jurors.

"*The Delandtsheer Machine.*—Taking the machines in the order in which they stood, the first was that invented by Delandtsheer, of Paris (Décortiqueuse de Ramie Systême Delandtsheer). The cost was stated to be £40. This was driven by steam power, and required two men to attend to it. It had a horizontal feed-plate, and consisted of a series of rollers and crushers, which received eight or ten stems at a time from the hands of the operator, and passed them on to be beaten by a

pair of rapidly revolving drums very similar in character to that found in the Death machine. In the Delandtsheer machine, however, there is a reverse action attached of an effective character. When about five-sevenths of the lengths of the stems had been cleaned, they are quickly returned by means of the reverse action to the hands of the operator, who then presented the unclean ends to the machine and completed the operation. The fibre in this case was only moderately well cleaned; there was considerable waste, and the actual amount of rather bruised ribbons was as follows—from dry stems, 5 kilos. per hour, and from green stems, 18 kilos. per hour. As the latter were weighed before they were dried, the calculations for dry ribbons would be about 6 kilos. If we take the result at $5\frac{1}{2}$ kilos. per hour of dry ribbons, the Delandtsheer machine would produce only 55 kilos. per day of ten hours, equal to about 120 lbs. avoirdupois. The commercial value of these ribbons at £7 per ton would be 7s. 6d.

"The inventor claimed for the Delandtsheer machine that it could produce 3 cwt. of dry ribbons per day. The small out-turn at the trial was attributed by him to the poor character of the stems supplied. There was some cause for complaint on this head, but in any case it was difficult to believe that this machine could produce, as worked at Paris, ribbons in commercial quantity at a remunerative cost.

(*To be continued.*)

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings at Eight o'clock:—

JANUARY 30.—"The Construction of Photographic Lenses." By CONRAD BECK. CAPT. ABNEY, F.R.S., will preside.

FOREIGN AND COLONIAL SECTION.

Tuesday evenings, at Eight o'clock:—

JANUARY 29.—"Gold and Silver Mining in the Rocky Mountains of Colorado." By THOMAS W. GOAD. SIR OWEN T. BURNE, K.C.S.I., will preside.

APPLIED ART SECTION.

Tuesday evenings, at Eight o'clock:—

FEBRUARY 5.—"Manufacture of Sèvres Porcelain." By EDOUARD GARNIER.

CANTOR LECTURES.

The following courses of Cantor Lectures will be delivered on Monday evenings at Eight o'clock:—

ALAN S. COLE, "Egyptian Tapestry and Textiles." Two Lectures.

LECTURE II.—JANUARY 28.—Complete robes and clothes found at Akhmîm compared with tunics of early Egyptians, of Hebrews and Syrians—Greek and Roman tunics—Ornamental bands, &c., on Akhmîm tunics—Various shapes of bands or *clavi*, of squares and roundels, *tabulæ adjunctæ*, and *caliculæ* compared with costumes shown in the wall paintings of Roman catacombs—Ravenna mosaics of Empress Theodora, &c.—Typical ornaments from Akhmîm compared with similar motives at Kermanchah—Persepolis—Cyprus—and in Roman mosaics from Constantine, Algeria—Barcelona, Spain; Christian symbols—Byzantine styles—Conclusion.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, JAN. 28...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. Alan S. Cole, "Egyptian Tapestry and Textiles." (Lecture II.)

Surveyors, 12, Great George-street, S.W., 8 p.m. Mr. Josiah Hunt, "Quantity Surveyors; their Duties, Rights, and Liabilities."

Geographical, University of London, Burlington-gardens, W., $8\frac{1}{2}$ p.m. Capt. J. Page, "The Gran Chaco (Argentine Republic) and its Rivers."

British Architects, 9, Conduit-street, W., 8 p.m.

Actuaries, The Quadrangle, King's College, W.C., 7 p.m.

Medical, 11, Chandos-street, W., $8\frac{1}{2}$ p.m.

London Institution, Finsbury-circus, E.C., 5 p.m. Mr. Armitage Bakewell, "Modern Wit."

TUESDAY, JAN. 22... SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Foreign and Colonial Section) Mr. Thomas W. Goad, "Gold and Silver Mining in Colorado."

Royal Institution, Albemarle-street, W., 3 p.m. Prof. G. J. Romanes, "Before and After Darwin." (Lecture II.)

Civil Engineers, 25, Great George-street, S.W., 8 p.m. 1. Mr. John Carruthers, "The Steep Incline on the Puerto Cabello and Valencia Railway, Venezuela." 2. Mr. Robert Wilson, "Cost of Working the Hartz Mountain Railway." 3. Mr. J. P. Maxwell, "Further Information on the Working of the Fell System on the Rimutaka Incline, N.Z."

WEDNESDAY, JAN. 30...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. Conrad Beck, "The Construction of Photographic Lenses."

Microscopical, King's College, W.C., 8 p.m.

THURSDAY, JAN. 31...Royal, Burlington-house, W., $4\frac{1}{2}$ p.m.

Antiquaries, Burlington-house, W., $8\frac{1}{2}$ p.m.

London Institution, Finsbury-circus, E.C., 6 p.m. Rev. Canon Benham, "The Times of the Twelve Apostles."

Society for the Encouragement of Fine Arts, 9, Conduit-street, W., 8 p.m. Dr. G. G. Zerffi, "Evolution in Art."

The Sanitary Institute, Parkes Museum, 74A, Margaret-street, W., 5 p.m. Prof. F. Jeffrey Bell, "The Worm Parasites of Human Food."

Royal Institution, Albemarle-street, W., 3 p.m. Prof. J. W. Judd, "The Metamorphoses of Minerals." (Lecture II.)

FRIDAY, FEB. 1...United Service Institute, Whitehall-yard, 3 p.m. Lieut. T. Y. Greet, "Coaling Ships."

Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting, 9 p.m. Prof. W. C. M'Intosh, "The Life History of a Marine Food Fish."

Geologists' Association, University College, W.C., 8 p.m. Annual Meeting.

Philological, University College, W.C., 8 p.m. Mr. T. G. Pinches, "The names Jah and Jahveh."

SATURDAY, FEB. 2...Royal Institution, Albemarle-street, W., 3 p.m. Prof. Ernst Pauer, "The Character of the Great Composers, and the Characteristics of their Works." With Pianoforte Illustrations. (Lecture II.)

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FRIDAY, FEBRUARY 1, 1889.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CANTOR LECTURES.

The second and concluding lecture of his course on "Egyptian Tapestry," was delivered on Monday evening, 28th inst., by Mr. Alan S. Cole. The lecture was illustrated by a large number of lantern slides of various specimens of tapestry, and copies of wall paintings from the Roman catacombs, for the purpose of comparison between the patterns and costumes as shown in the paintings and on the tapestry.

General Donnelly, C.B. (Chairman), proposed a hearty vote of thanks to the lecturer for his interesting course of lectures.

The lectures will be published during the summer recess.

LIST OF MEMBERS.

The new edition of the List of Members of the Society is now ready, and can be obtained by members on application to the Secretary.

COVERS FOR JOURNAL.

For the convenience of members wishing to bind their volumes of the *Journal*, cloth covers will be supplied post free for 1s. 6d. each, on application to the Secretary.

Proceedings of the Society.

INDIAN SECTION.

Friday, January 25, 1889; Major-General Sir Frederick J. Goldsmid, K.C.S.I., C.B., in the chair.

The paper read was—

THE ASIATIC COLONISATION OF EAST AFRICA.

By H. H. Johnston, F.R.G.S.
H.M. Consul, Mozambique.

On previous occasions when I have had the honour of addressing the Society of Arts, I have dealt, directly or indirectly, with East African subjects generally bearing on our commerce in those regions. Hitherto I have principally considered the aspects of this part of Africa in relation to European trade and political influence. I now propose to take up the interesting consideration of the part which Asia has played in the affairs of East Africa, and on this subject I propose to address you to-night.

In whatever quarter of the globe the human race may have originated—whether it was, as some suppose, in the icy north, or in the rank forests of equatorial Africa or the Malay peninsula, or on the steppes and plains of central Europe—it is hard to decide; but it is certain that in Asia man effected his first decided concentration, and from its Asiatic home the human species spread out east, and west, and south. From Asia, from the continent that will always be known as "The East," just as America must remain the typical West, has radiated horde after horde of hungry peoples, and wave after wave of conquest—either political or commercial—over the outer lands of Europe, Africa, and Polynesia. From Asia most of the arts and sciences come, and in Asia most of our important domestic animals and cultivated plants were probably first developed from the wild species. Only in the 16th century, after the discovery of America by Europeans, did this movement receive a check, and the invasion of American products bring about a reversal of this procedure, when the turkey and the Muscovy duck were sent from the West to that East which gave

us the domestic fowl and the peacock; when maize was the return offering for rice, and the potato was sent as an equivalent for the banana; the pine-apple, guava, cactus, and tomato were exchanged for the orange, lemon, and mango, and the many varieties of plums, from cherries to peaches; the apple, pear, the quince, first cultivated in the cooler lands of Western Asia. Asia and America, in fact, share between them the glory of having fed and civilised the human world. Europe has been little more than an *entrepôt* and exchange for the products of both, and Africa—poor, barbarous land of the blacks, still in the Pliocene epoch as regards its natural condition—has only begun to yield its native wealth; and the most premature of its contributions—coffee—we owe more to the fact that it grew in that part of Africa most closely touching Asia, while its first cultivation actually took place in the peninsula of Arabia, which is, geographically, part of the Asiatic continent.

It is almost certain that Africa received the first invasions of the human race from Asia, which, having regard to the actual land communication still existing, and the probability that the Red Sea has been several times dry land, is not surprising. I would not postulate the theory that none of the lower and earlier races of men that existed in Mediterranean Europe did not find their way into Africa; it is probable that they did, but it is not unlikely the part of Africa then reached — Africa north of the Sahara—was at that time cut off from Tropical Africa by an intervening sea or gulf, while, at the same time, the land connection of North-East Africa with Western Asia was probably more extended and continuous than at present. The modern fauna of tropical Africa, excluding Madagascar, is much the same in character as that which prevailed over Europe and Western Asia before the glacial epoch, or whatever was that climatic change in Northern Europe and Asia which substituted an Arctic fauna and flora for a tropical; but the elephants, giraffes, and lions, the apes, baboons, and hippopotami, the antelopes and ostriches, which invaded Africa and ousted its feeble indigenous edentates, insectivores, lemurs, and viverine carnivores, may just as well have come from Western Asia as from Greece or Sicily. We know that the ostrich, the baboon, several antelopes, and the lion still exist in Arabia. All the creatures I have mentioned, except perhaps the African elephant, are found in a fossil state in Western India, the remains of the ostrich, hippopotamus, and giraffe being so recent as to suggest that they must have lingered almost to the historical period. The peninsula of Arabia, which is half African in the character of its fauna and flora, seems to have been a remarkable half-way house (no doubt under different climatic conditions), not only for birds, and beasts, and plants, but also for the human species. Little as this most interesting country has been explored, and small as are the researches into its geological history which the provoking fanaticism and race jealousy of its inhabitants have permitted us to make, we still know enough of its ethnological records to advance the theory that Arabia has in the past history of the world been traversed by many nations and tribes and varieties of man crossing from Asia into Africa. This way the ancestors of the negro race entered Africa, preceded, possibly, by the very low negroid form represented by the modern Bushmen and Hottentots, which, degraded as their physical condition has become—and, as regards their bodies, they may be said to have added retrogression to an originally low development—still in their forms of speech offer some slight signs of connection with the parent form of the Hamitic family of languages, some such mother tongue as originally gave birth to the ancient Egyptian and the modern Galla, Berber, and Hausa languages. No doubt somewhere in Southern Asia—perhaps in that hive of races, India—existed the original *foyer* of the negro race. From some low negrito form of man—a form no doubt once widely spread over Europe and Asia—was differentiated the true negro, who spread westward, and the Papuan, who spread eastward. The negro type, in passing through Persia, Mesopotamia, and Arabia, has left decided traces of his passage. Besides the credible reports of classical geographers and historians of black-skinned people inhabiting Eastern Arabia and Southern Persia, there is a distinct evidence of negroid affinity among some of the existing populations of Beluchistan, the Euphrates delta, 'Oman, and the Hadhramaut, which—especially in the countries first-named—cannot be accounted for by the supposed and unrecorded importation of a large number of negro slaves. It must not be forgotten, indeed, that, as regards race and language, there are quite sufficient links existing to connect the Arab and the negro with a chain of intermediate types, though, no doubt, the differentiation between the white

Semite of Western Asia and the Ethiopian took place before the latter entered Africa, the yellow negrito parent form intensifying on the one hand into the coal-black negro, and mounting up on the other through the sallow Hamite into the white Arab, and the ruddy-cheeked Assyrian. The first immigrants from Asia were, no doubt, the lowest negro forms—the ancestors of the Bushmen—and then succeeded wave after wave of negroes and negroids, the lower races preceding the higher, which in turn were forced from Asia into Africa by the necessity for finding fresh homes and subsistence. After this age of continued movement between Asia and Africa, there was, no doubt, a kind of lull, when the negroes and the Hamites settled down to colonise tropical Africa and the Valley of the Nile, and the Semites concentrated themselves in Western Asia and Arabia. But the rapid development of civilisation among the Semitic peoples, and the impetus given to Indian commerce in the Aryanising that followed the invasion of that peninsula by races akin in origin to our own, once more turned the attention of the enterprising, restless Asiatics towards the land of Cush. The Phœnicians began to launch their ships on the Red Sea, and sail down the eastern coast of Africa, attracted by the gums and spices of Somaliland, and the gold and silver of the Zambesi countries, and possibly also by the desire to obtain negro slaves, the value of the brute labour of the curly-haired, black-skinned, Ethiopian having already been proved by the Egyptians, from whom no doubt the Phœnicians, in vulgar parlance, "got the tip," the Egyptians of course having already considerably exploited the land of the blacks, although as being themselves an African people, I do not intend to review their proceedings in connection with my present subject. But it was no doubt from this great race on the Nile—this first of great races in human history—that the enterprising Phœnician Semite, and the almost Asiatic Greek, first heard of the riches and wonders of Ethiopia. The Phœnician brought gold and ivory, and apes (probably baboons), and, no doubt, also negro or Abyssinian slaves to the only Jewish king who made a name for himself among his contemporaries outside restricted Palestine. The Phœnicians also, no doubt, taught the early navigators among the Himyaritic Arabs, and on the shores of the Persian Gulf, and the corrupted Aryans of Western India, to seek the east coast of Africa with a timid, fluctuating commerce. The Indians attracted possibly even the Chinese, whose junks, it may be, accompanied the sailing craft that sailed with the north-east monsoon round the coast of Arabia to the regions of Zanzibar. Before this development, however, of the oceanic trade between Asia and Africa, there had probably been two or three distinct and unrecorded Asiatic settlements in East Africa, which occurred before the dawn of history, but after the populations of Asia and Africa had become tolerably settled in their present characteristics. I refer to the Semitic colonisation of Abyssinia and districts, like Harrar in the interior of Somaliland, and the Malay invasion of Madagascar. It is probable that the ancestors of the Hovas already found Madagascar, or the western side of it, inhabited by negroes, whom to a great extent they absorbed rather than exterminated.

It is no doubt probable that the prevailing winds over the Indian Ocean, blowing in a very decided manner, first from the north-east and then from the south-west, greatly assisted the tentative efforts of the Asiatic navigators to cross to East Africa, and possibly in the case of the Malays who invaded Madagascar, the force and direction of the wind brought their frail craft to that island, rather than any deliberate effort on their part, to seek new homes beyond the sea. Whether the Chinese actually traded direct and personally with the Zanzibar coast, whether their junks actually visited these shores, is doubtful, although the amazing quantity of Chinese pottery and coins which have been found on the littoral of East Africa show us that, whether or no Arabs, Persians, or Indians acted as intermediaries for the Chinese, a very large ancient trade must have existed between China and the Zangian coast, and it would even seem as though much of the ivory used by the Chinese in ancient as well as in modern times was rather derived from African sources than the poor supply afforded by the Asiatic elephants, and it is claimed, too, that the cultivated members of the orange family found so abundantly along the East African littoral, and evidently of ancient introduction, were derived from China (where the orange family is indigenous, and was first cultivated) at a much earlier period than they were spread through Southern Europe by Byzantines and Arabs. The history of the orange and the sugar-cane, indeed, are among the most interesting of the episodes attending the spread of civilisation. The sugar-cane and the orange,

first cultivated in Eastern Asia, were carried to the Mediterranean Basin by the Phœnician, Persian, and Arab; the latter in the wave of Saracenic conquest brought these valuable products into the Lower Roman Empire, and especially implanted their cultivation in that Iberian peninsula where the Arab intellect reached its finest development. The Portuguese and Spaniards, with a happy but almost unreasoning instinct, transported the orange and the sugar-cane to their New World in the western hemisphere. Meanwhile the Saracen, succeeding to the heritage of the Phœnician and Persian, thrust the sugar-cane, and the orange, and the cultivated banana (not the plantain) into every part of the East African coast between Abyssinia and Zululand. The Portuguese turned their attention to Western Africa from South America in the 17th century, and introduced the orange, the sugar-cane, and the banana, together with other purely American products, from Brazil into various points on the west coast of Africa. Thence travelling slowly inland, across the continent, by the Congo or up the Niger, or across Angola, these introductions of the Portuguese will meet in the centre of the continent the orange, sugar-cane, and banana, which have come from the East, where they were introduced by the Arabs.

A slight study of the present domestic animals of Africa will show that they are all exotic in origin, and, with the sole exception of the Muscovy duck, which is an American importation that we owe to the Portuguese, all the domestic animals and birds of Negro Africa have come from Asia; and this fact, if for no other reason, is patent from the consideration that the wild originals of the negro's domestic animals are indigenous to Asia and not to Africa. Oldest of all, the dog is similar in form, shape, and colour to the pariahs of India. The goat and the sheep are closely allied to Asiatic varieties. The ox is either a degraded zebu, or belongs to a long-horned large breed, similar to the domestic cattle of Western Asia and Central Europe. The fowl, the pigeon, the pig, the cat, the horse, and the camel all had their wild originals in Asia and not in Africa; the sole exception is the domestic donkey, which springs from the Abyssinian wild ass found in North-East Africa.

About the early Phœnician colonisation of East Africa, and the first movements of the South Arabians in that direction, we have, after all, only vague conjectural opinions, based on a few meagre traditions, and perhaps on the inferences we form from archæological discoveries; but concerning early Persian immigration we know considerably more. The Persian invasion and conquest of Egypt under Cambyses probably first directed the attention of Persia in any marked degree towards the East African coast. No doubt before that time such commerce as she may have held with East Africa was transacted through the Arabs and Phœnicians rather than by direct intercourse; but about the 5th century after Christ we have the first definite account of Persian settlements on the Zanzibar coast. During the first half of the Christian era, the Persian settlements at places like Lamu and Kilwa became so populous that they have left to this day a distinct trace in the features of the inhabitants; such, that is, as belong more or less to that curiously mongrel Swahili race which is compounded of Arab and Persian mixtures based on the original Bantu stock, whose language contains a not inconsiderable number of Persian words, and whose customs, in spite of Mohammedanism, have incorporated many Persian rites. The development afforded to Arab enterprise and commerce by the rise of the Saracenic empire, caused the Arabs to invade the east coast of Africa in the same vigorous fashion in which they assailed Southern Europe and Western Asia. This brought about the downfall of the Persian kingdom and colonies, and the Arabs supplanted and absorbed them, although the trade which had sprung up between Persia and East Africa rather went on increasing slightly, century after century, especially as the common bond of Mohammedanism, to a great extent, knit Arab and Persian interests together. During the 12th century, the Arab dominion on the east coast of Africa had reached its apogee of splendour. Mosques and palaces were built in all directions, and in places that now puzzle the explorer as to their fitness for trading settlements; places where the silting up of sands, or the growth of coral reefs, or other causes, have destroyed the practicable port that once existed. In travelling along this now much depopulated coast it is no uncommon thing to find in some thorn thicket, or some luxuriant grove of lush tropical vegetation, the crumbling arches of a mosque, the delicate stonework which enshrines a mihrab, or some quaint tomb or pillar, which are relics of a chaste style of Saracenic architecture, rather recalling that which prevails in Syria than the less pure modern Persian style. These ruins must have been handsome buildings, or stately

monuments in some populous centre of trade and semi-civilised rule. Often the walls of the mosque, or the corners of the arch will be stuck with beautiful Persian, Syrian, or Indian pottery, plates, or bowls that are imbedded in cement. Indeed, this fashion of decorating the interior with pottery still prevails on the coast, and is pushed to an almost exaggerated extreme in some Suáhili towns, such as Lamu or Malindi. A magnificent collection of this pottery has been formed by Sir John Kirk, for many years our distinguished political agent at Zanzibar. It is mostly Persian, but there are some splendid samples of Chinese art dating from a period as far back as the 12th century, down to a hundred years ago. To the former period belongs some very beautiful green Celadon ware which is not uncommonly met with on the Zanzibar coast.

About 900 years ago there was a renewed Persian colonisation of East Africa, which principally centred on the districts south of Zanzibar, and was incidentally the cause of the creation of the powerful Sultanate of Kilwa; but this was the last expansion of Persia across the seas, and gradually her East African settlements were again dominated and overrun with Arab immigrants, although it is to be noted that these latter proceeded principally from the Persian Gulf—from the Imamate of 'Oman. The Arabs were in full possession of the coast from Somaliland to Sofala when the Portuguese first rounded the Cape of Good Hope, and it was Arab pilots that showed Vasco de Gama the way to India, a service which the Portuguese somewhat ungratefully repaid by taking East Africa from the Arabs. A curious trace of the southward extension of Arab influence remains in the cant name of one of the most important races in South Africa. The Portuguese at Sofala, asking the name of the local races from the Arabs, were told that they were "Kufar"—or, in the singular, "Kafir;" that is, infidels—heathen; and this term the Portuguese forthwith applied to the South African negro races, and we in turn blindly adopted it from the Portugnese.

In reading the history of the Portuguese conquest of East Africa, which at one time extended from Abyssinia to Delagoa Bay, along the coast, one cannot fail to be struck with the fierce bravery of the small bands of men who held that great littoral of East Africa, together with Aden, 'Oman, Ormuz, and Western India, and the great Malay Islands, for the King of Portugal, the monarch of that tiny European State who to this day calls himself, with a sad magniloquence in his sonorous language—"King of Portugal and the Algarves on this side and the other side of the sea in Africa; Lord of Guinea and Master of the Conquest, and Navigation of Ethiopia, Arabia, India, and Persia." Nor can one minimise the profound effect on the civilisation of Europe which the Portuguese conquest of the East produced, scarcely less in its way than the Spanish conquest of the West. But in the 17th century the uprising of the coast Arabs—a movement of something the same character, and produced by the same causes as that which has caused the present overthrow of German settlements in the same quarter—drove the Portuguese from all their possessions except Mozambique, which stronghold, through the treachery of an Indian trader—if "treachery" can be applied to an act so beneficent to civilisation—saved the fortress of Mozambique from the Arabs, and preserved the continuance of Portuguese power in East Africa, which, if impartially considered, will be found to have done far more good than harm, though at the present day we are apt to become impatient when the Portuguese cling to the shadow of what was once a substantial fact. The Arab rule having recovered the East African coast, in what are now—or rather were before the present scramble—the Sultan of Zanzibar's dominions, proceeded as usual to resume their internecine strife between faction and faction, and family and family. Among the more powerful clans were the Mazrui, who frequently held Mombasa, and proclaimed alternately their independence of Zanzibar, or submitted perforce an unwilling allegiance to the Sultan of that island. It is interesting to note that the lineal descendent of this family of Arab chiefs is the tolerably well-known Mubarak, who is still living in the vicinity of Mombasa, who for years past carried on an unsuccessful struggle with the late Sultan of Zanzibar, endeavouring to assert his right to be the independent ruler of Mombasa. Indeed, the uprising of one of this man's ancestors against the over-lordship of Zanzibar at the beginning of this century was the cause of the first deliberate British intervention in the affairs of East Africa. At the invitation of the Mombasa insurgents, who had thrown off the Sultan of Zanzibar's authority, a British force, in 1822, occupied Mombasa, and a naval man was appointed governor. This was in the days before the telegraph existed, and when British officials in the East acted a good deal

more on their own responsibility. Had the British occupation of Mombasa been confirmed, the whole of East Africa would probably now have become an annexe to British India, for the people of the coast were willing, and anxious even, to be under British rule, but, unfortunately, the Governor of Bombay, at that time out of consideration for the feelings of our faithful ally the Imam of Maskat, revoked the proceedings of Captain Vidal, who had hoisted the British flag at Mombasa, and restored that place to the ruler of Zanzibar, a lieutenant of the Imam of Maskat. Ever after the protracted squabbles of the Arab clans in East Africa, which I have already alluded to, the rising power of Maskat, strengthened especially by the expulsion of the Portuguese from 'Oman, and the Persian Gulf asserted its sway over Zanzibar City, Island, and Coast, where they have ruled uninterruptedly since the beginning of the eighteenth century; although, about nineteen years ago, the Sultan of Zanzibar was politically detached from the Imamate of Maskat, in much the same manner as Brazil was separated from Portugal, a branch of the royal family continuing to rule in the enfranchised dependency.

When the first traders from India established themselves in Zanzibar it is difficult to ascertain, but they probably did not settle there in any considerable numbers until the advent of the Portuguese, who opened up a lively intercourse between their possessions in East Africa and their settlements on the west coast of India. That the Indians appreciated the advantages of Portuguese rule is apparent from the manner in which they appear to have generally taken sides with the Portuguese against the Arabs.

All through the British conquest of India and access of naval strength in the Eastern seas, which, during the present century, caused the great revival of an Asiatic colonisation of Africa, the protection and support that was freely granted by the administration of the Honourable East India Company to Indian subjects abroad caused the natives of India to realise, for the first time, the advantages of being British subjects, and they applied themselves with such confidence to the exploitation of Zanzibar that, by the beginning of the century, they had completely got the local commerce into their hands, and had attained to very great power and influence as the advisers and financial administrators of the Arab ruler. Indian merchants farmed the Customs of Zanzibar until 1885, and one of the greatest of these contractors, the celebrated Jayaram Suji, died worth over a million sterling, a fortune founded on the sum derived from the difference between the settled income paid to the Sultan yearly and the actual revenue gathered in at the Custom-house. Even one of his leading clerks managed to save £40,000 out of legitimate pickings that fell to his share; and if it is plain that the British Indians profited largely by their manipulation of the fiscal policy of Zanzibar, it must also be remembered that the huge increase in the trade of these dominions was owing to British Indian enterprise and industry. At the beginning of this century the British Indian subjects in Zanzibar scarcely numbered over a thousand. Now their number probably exceeds 7,000. There was a considerable increase in the immigration from 1870 to 1885, during the residence of Sir John Kirk as Consul-General and Political Agent; and you have only to read the local Indian press during the last two or three years, to realise how fully our British Indian fellow-subjects appreciated the wisdom, tact, and courtesy of Sir John Kirk, and how they regretted the necessity for his rest and retirement.

The British Indian colonists or traders in the Zanzibar dominions come under the following designations:—Hindus, who number about 1,000; Parsis, about 100; Khojas, who are the most numerous, reach probably a total of 4,000; and the remainder of the 7,000 British Indians who are registered at the consulate are made up of Bohras and Memons. There are, besides, about one hundred so-called Goanese, who vacillate in their allegiance to Portugal or Britain.

The section of British Indian immigrants coming under the designation of Hindus are almost entirely Bhattias or Banyans of Cutch, who, even in the time of the first Portuguese visitors, appear to have been the most thriving and enterprising of the foreign merchants of Zanzibar.

At first they were obliged to travel to Zanzibar by way of Maskat, in a certain ship which sailed once a year; they were exposed to many hardships and peril; they were often murdered, and when they died at Zanzibar their property was not infrequently seized and divided among the Arab chiefs. By dint of commercial integrity, frugality, and dogged perseverance, and the inability of the Arabs of Zanzibar, like the Arabs everywhere else, to manage accounts or bank-

ing, they acquired very great influence over the country ; in fact, they have become at Zanzibar what the Jews are in Morocco, the Maltese in Tunis and Tripoli, the Armenians in Asia Minor, Syria, and Persia, the Greeks in Egypt, and the Parsees in British Arabia; but by their greater fairness, kindliness, and placability, they are more favourably regarded by the proud, idle races they exploit than are the trading aliens in the other Mohammedan countries to which I have alluded. In fact, the Banyans have considerable power over the Arabs and Waswahili, and even over the interior tribes of the Zanzibar littoral. It is no secret that much of the recent troubles and difficulties of the German Company in East Africa arose from the unwisdom of its *employés* in endeavouring to rudely and suddenly oust the Indians from their commercial supremacy, and in thereby making Indian sentiment opposed to the extension of German rule. Though the Banyans rarely leave the seaboard, they command the inland trade, sending where they themselves do not care to travel caravans of Arabs and Wasawhili to conduct a trade which they, the Indians, finance. I have, however, met Indians occasionally as far inland as the flanks of Kilima - Njaro, where a few years a years ago they were reviving a brisk little commerce in slaves with the well-known chief, Mandara, until this was discovered and promptly put a stop to by Sir John Kirk, who sentenced the Indians in question to various terms of imprisonment. Indians also travel now as far as Wunyamwezi, that country which is a kind of rendezvous for the Victoria Nyanza, Tanganyika, and North Nyasa caravans. It is to be feared that, although they nominally profess simply to buy ivory in these distant excursions, they also purchase considerable numbers of slaves, which, however, they are too wise to export, but dispose of on the coast. Happy the lot indeed of the slave who comes into the possession of the "mild Hindu," who is invariably kind to his dependents, and if slavery is tolerable at all, it is the kind of quasi-servitude which prevails among such British Indians as inhabit the mainland of East Africa. Indeed, as has been several times pointed out by those who are really acquainted with Africa, the recent slightly ostentatious crusade against slavery is somewhat misdirected in its objects. The wicked part of African slavery is the slave-raiding which is carried on in the very heart of the Continent by Arab mongrels or Mohammedanised negroes. These raids, it must not be forgotten, prevail quite as much, perhaps even more, in the Western Sudan at the back of the Niger and Benue, and to the south of Darfur, as on the Upper Congo, or in the Nyasa region, and can only be put a stop to by the gradual occupation and administration of these lands by a European power. This end will unquestionably be brought about by the development of the Congo Free State, by the extended rule of the British in the Niger territories, and by the establishment of British, Portuguese, and German administration in the Nyasa countries and on the Zambezi. But once the slaves are captured and reach the coast, at the present time, their fate is then not a hard one by any means, unless their Arab owners should endeavour to export them, and the daus in which they are travelling be sunk by the well-meant but rather cruel kindness of British cruisers. Consequently an ill-judged interference with domestic slavery on the East coast of Africa would at present be very regrettable, and should not be attempted until those countries are administered by thoroughly settled forms of English and German government. I do not, therefore, wish you to think that much harm is done by the British Indians purchasing and holding so-called slaves, because these slaves are free in the eye of that law to which British Indians are subject, and their condition is scarcely different from that of domestic service in England.

Wherever you meet a Banyan on the coast you meet a banker who has an unbounded faith in the credit of our nationality, and will cash your note of hand for considerable amounts with a readiness and facility which I trust have seldom been abused. There have been, I have heard, one or two cases in the history of East African exploration where European travellers have made dishonourable use of the Banyan's trust in their good faith, but when this has happened the leading merchants of Zanzibar, English, American, German and French, have subscribed to make the defalcations good, so thoroughly did they appreciate the necessity of maintaining the confidence felt by the Banyans in the honesty of Europeans.

The Bhattia or Banyan at Zanzibar is, properly speaking, a visitor and not a colonist. He arrives to begin his apprenticeship in the trade as a mere child, of course under the guardianship of some relation. After a residence of about ten years in East Africa, he

returns to India to get married. When his honeymoon is over he leaves his wife behind and resumes his trading in East Africa. A strict regulation of their caste apparently forbidding them to take their women out of India, no Hindu woman is ever seen at Zanzibar; but their husbands are likewise bound by the regulations of their order to return to their wives in India every four years. Not infrequently, however, absence fails to make the heart grow fonder, and the Banyan finds such abundant consolation in the female society of Zanzibar that he neglects to return to India to his grass-widow within the prescribed limit of time; and Sir John Kirk tells me that in cases like this, he has not infrequently received applications from India, from the wife or relations of the faithless swain, to compel him to return to his wife and family, and that to his formal declaration of inability to take such action he has added a rider to the effect that if these Hindu women are so foolish as to allow a tradition to prevent their doing their duty as wives and accompanying their husbands on their journeys, they are justly punished for their bigotry by abandonment. The Banyan men are generally amply consoled for this separation from their lawful wives, which the foolish tenets of their religion enjoin, by the affections of the Arab women whom they may take as partners in Zanzibar. The Arab women often prefer union with a Banyan to a man of their own nationality, because the former is generally of a kinder disposition, and is, moreover, usually a monogamist.

The Banyans are forbidden by their caste regulations to sell animals. They may not traffic in kauri shells, because this causes the death of a mollusc, but they evade the law in some casuistic way, and permit themselves to trade in hippopotamus tusks, rhinoceros horns, and ivory, and even hides, though this latter infraction caused such a scandal some years ago that their Maharaja—their high priest—sent a Chela—or disciple—from Malwa, to investigate the matter. Covered with ashes, and carrying an English umbrella, the holy man arrived in a severe mood. He rejected all civilities, and merely acknowledged the addresses and salutations which he received with a peculiar bellowing grunt. The result of his visit was a fine of 40,000 rupees, imposed upon the well-known merchant, Jayaram Suji. The Banyans, as a matter of duty, still protest against the slaughter of cattle in Zanzibar, especially in public, but the intensity of their feeling on this point appears to be waning, and it is evident that, as usually happens, foreign travel, and life outside their own country, have tended to sap such religious sentiments as are in dissonance with a practical view of life. It is a pretty sight, in the streets of Zanzibar or in some coast town, like Pangani, Mombasa, or Kilwa, to see the great white or dove-coloured cattle of the Banyans sleepily chewing the cud in the shade of the overhanging eaves of their owner's dwelling.

The Banyans, with their long, limp, black hair, generally coiled up underneath the turban, their regular features, pale ivory-coloured skin, and fine eyes, are a pleasant, wholesome contrast to the frowsy olive-skinned Arab, with his hungry, hawk-like face – often pitted with small-pox—or the prognathous bullet-headed negroes. The Banyans always look neat and clean in public. Their turbans are generally of some crimson stuff, wound round their coils of black hair in a complicated manner, with a kind of horn, or peak, formed over the forehead. They wear closely-fitting white cotton coats, with some shawl or unicoloured cloth thrown over the left shoulder. The legs are generally encased in tight, white cotton trousers, and some bright coloured Indian cotton is wound round the loins. The Bhattias far outnumber the other Hindus in Zanzibar, among whom there are a few Wanyas—Wanya is supposed to be the origin of the Portuguese corruption, "Banyan"—Brahmins and Khattris.

The few Parsis there are mostly bankers, and are connected directly or indirectly with the great house of Kawasji, Dinsho and Co., of Aden. The Mohammedans, or quasi-Mohammedan Indians, as I have already indicated, considerably outnumber the Hindus in the Zanzibar dominions. They are principally represented by the Khojas, who belong to the strange Mohammedan sect which is ruled over by the celebrated Aga Khan, who resides in Bombay. This sect, which has grafted Mohammedan tenets on to Hindu metaphysics, originated about the beginning of the 10th century in Persia, and afterwards spread to Syria, where it was subsequently known as the sect of "Ismailis." In the 11th century these Ismaili doctrines, which were really the development of the Shia faith, held that there had been repeated incarnations of God on earth, who especially revealed himself in Ali the son-in-law of Mohammed, his two sons, Hasan and Husein, and their further descendants, Zein-aladdin, Mohammed Baukr, Jafir Saiduk, and

Ismail; from which last manifestation of Allah the sect in question took its name. These beliefs were taken up and fashioned into a more logical faith by the celebrated Persian, Hasan Bin Saba, who founded the remarkable community known as the "Assassins,"* the chief of whom, from his stronghold in the Caucasian Mountains and in the Lebanon, came into contact with the European invaders of Syria during the Second Crusade, and the emissaries of this terrorising sect several times found themselves in the presence of our English king, Richard Cœur de Lion. After many vicissitudes in Persia, the 19th century head of this Khoja, or Ismaili sect, who, of course, was hypothetically descended from Ismail, the descendant of Ali, rebelled against the Persian Government and fled to India, in 1840, where he was enthusiastically received by his wealthy adherents in Sind. Here he raised and maintained a body of light horse, which he placed at the service of the British Government during the first Afghan war. For this service, and others which he rendered during the conquest of Sind, the Aga Khan received a pension from the British Government, which I believe his descendant still enjoys. The term "Khoja," I am informed, means "The Honourable," or "Worshipful" person, and also "the Disciple." I should imagine it to be none other than a corruption of the Arabic "Khawajah;" but on this subject I speak with considerable trepidation in the presence of so distinguished an Orientalist as our chairman of this evening. With regard to the early history of the Ismaili sect, I might note one or two interesting facts:—That the origin of what is now an ornamental sinecure, the Corps of Gentleman-at-Arms in our English court, was a guard of Norman officers specially formed by Richard Cœur de Lion to guard him from assassination by the emissaries of the Old Man of the Mountain; and, further, that the rulers of England and adherents of the Ismaili sect never stood face to face after Richard the First left Palestine till her Majesty Queen Victoria, in 1874, received at Windsor the well-known Taria Topan, a Khoja merchant of Zanzibar, who accompanied the late Sultan Barghash-Bin-Sa'id on his visit to England, as private secretary and minister. The Khojas in Zanzibar remit large sums to their Aga Khan at Bombay every year, and not infrequently die leaving him considerable legacies out of their property. Indeed, as regards this, there are often unpleasant rumours afloat about Zanzibar, for it is remarkable that whenever a devout Khoja has been persuaded to make his will in favour of the Aga Khan he is soon afterwards taken exremely ill, and dies with considerable suspicion of having been poisoned. In fact, the worst feature about the Khojas is the horrid stigma of secret assassination which still attaches to them, and descends from the days of the Old Man of the Mountain, although they now substitute the poisoned bowl for the dagger. Some very unpleasant cases have occasionally cropped up as side issues in legal proceedings at the Consular Court in Zanzibar, and I believe that on several occasions conviction for murder has followed investigations, and showed a decided bent for secret poisoning to exist among the Khoja community of Zanzibar. But the Khojas have also produced very fine, able, loyal men among those who have made large fortunes in Zanzibar, who view such proceedings as I have hinted at with the utmost abhorrence, and who are strongly in favour of the spread of education among the members of their sect, and indeed but for the secret opposition of their Aga Khan in Bombay, who is, I understand strongly opposed to the spread of education as a fatal solvent of absurd beliefs, very spirited measures would have been taken by the leading members of the Khoja community at Zanzibar to found schools for the education of their people. As a matter of fact, the well-known Taria Topan placed £20,000 some years ago at Sir John Kirk's disposal for the purpose of founding a thoroughly good school in Zanzibar, but the Aga Khan indirectly intervened, and forced Taria Topan to turn the school into a hospital, which has proved but a mediocre success. Their women, which unlike the Banyans they freely bring to Zanzibar, are of course utterly without education. They are not allowed to possess property in their own names during their husband's lifetime, and after his death, as widows, they cannot dispose of their husband's property except for a religious purpose. This leads to a great deal of wrong-doing, because a woman, in a merely dog-in-the-manger spirit, will sometimes bequeath her money to the Aga Khan out of pique, to prevent her husband's money coming to his children or relatives after her death. The other Mohammedan Indians of Zanzibar, such as the Bohras, who are Shias, and the Memons, who are Sunnis, do not offer any remarkable characteristics. They are patient, quiet, and industrious.

* From "Hashishin," eaters of *hashish* (hemp)—madmen.

One important Asiatic race which, much less in present than in past times, has been very prominent on the coast and in the island of Zanzibar, especially in the service of the Zanzibar sultan, is the Baluchi, who is principally there as a ragged soldiery for fighting purposes. The Baluchis originally came from the coast of Baluchistan, nearly opposite 'Oman. They seem to be entirely the Persian, Aryan Baluchi, and not the mysterious non-Ayran race of Baluchistan, the Brahuis. The Zanzibar Baluchis are comely-looking men, with almost European features. They are—everybody says—wicked, unscrupulous cut-throats, and pilfering thieves, but there is a dare-devilry and handsome swagger about them—a general "niceness," as an enthusiastic lady, with an eye to the picturesque, once vaguely remarked to me, which makes one inclined to view them far more sympathetically, and wish more sincerely to reclaim them to better ways, than the unprepossessing Arab, the sly Khoja, or the sleek Hindu.

To conclude my *resumé* of the Asiatic immigration into East Africa, I may mention that, besides the pre-historic Malay invasion of Madagascar to which I have already alluded, a more recent colonisation of some of the Comoro Islands—Comoro is a corruption of the Arabic "Kamar," which means full moon—has taken place by Javanese and Bali people. How they got there I do not know, but they do not appear to have been there more than two or three hundred years. The other inhabitants of the Comoro Islands are half caste Arabs, or negroes, allied to the Waswahili of Zanzibar.

I cannot but think that the well marked Asiatic element in the civilised, or semi-civilised, population on the east coast of Africa will have a very important *rôle* to play in its ulterior development; and as the large majority of these Asiatics are British subjects, they are a quite sufficient excuse for the keen interest which England takes in the political future of the Zanzibar dominions. The until recently flourishing commerce of Zanzibar has been almost entirely built up by their energy and industry, though they have been aided, no doubt, by the advantage of enjoying the ægis of the British empire. I am glad to note that, among other wise and discreet points in the policy of the new British chartered company which is to govern a large section of the Zanzibar dominions in the name of the Sultan, has been the hearty encouragement they have shown to British Indian immigration, and this company proposes to offer every facility for the settlement of Indians as cultivators in the rich but sparsely inhabited lands of the interior, between the Victoria Nyanza and the coast, where cattle breeding and corn growing could be carried on to a great extent, and where there is every range of climate, from the snowy peaks of mountains that recall the ranges of Northern India to the hot plains, like those of the Dekkan, or dank forests similar to those of the moist regions of Southern India. So, in time, we have good reason to hope that the views of the far-seeing Indian Civil servants at the beginning of this century, who founded that policy in Zanzibar, of which Sir John Kirk became so able an exponent, will be realised, and British East Africa will become the granary, the market for the manufactures, and the home for the overflow population of British India.

DISCUSSION.

Mr. HYDE CLARKE said one never listened to Mr. Johnston on any part of Africa without acquiring a great deal of information. He would take the liberty of calling his attention to one small part of the subject to which he had not referred on the present occasion, that was the part which the British Indians took in our Cape colonies, particularly in Natal. A movement had been going on there for a few years, under which the coolies had become possessed of a great deal of the shopkeeping-business in the Natal colonies. Indeed, to such an extent had this taken place that at Pietermaritzberg the English storekeepers had been pretty well compelled to abandon the place. This was not altogether a complete benefit, the result was that the large establishments which were formed by Englishmen, and the community of enterprising and able men that had sprung up there, had been completely displaced. Their properties were on sale on very low terms, because of course there was no one to take them. The Indian shopkeeping operation had likewise this consequence, that the coolie, after his term of service, instead of going on contributing to the agricultural industry of the colony, turned shopkeeper. The condition of Natal industrially had been a good deal changed by this. By the last mail he noticed that a cargo of 300 coolies had arrived in Durban, and there could not be much doubt that in time they would be a contribution to the small shop-keeping community rather than the industrial population of the colony. This was a subject which touched a great many of our merchants. On the other hand, as far as our Indian friends were concerned, they got some advantage; our home traders were displaced, except that at the

present moment some of the wholesale establishments had been removed to the port of Durban, instead of remaining up-country. Their goods were supplied sometimes direct from Bombay, to the advantage of British India; whilst, as he had said, a displacement took place as to our direct home trade. This was a confirmatory example of what Mr. Johnston had said as to the activity, energy, and enterprise of our British-Indian subjects on other parts of the coast. There was one matter which Mr. Johnston, very naturally in his position, did not refer to, that was the part which was being taken by our kinsmen in Germany at the present moment, which, with all our desire to promote their alliance and to give them special advantages, went beyond simple colonisation, and beyond commercial policy. Mr. Johnston had shown that it was in fact by our Indian Government that this great movement in the progress of civilisation—the introduction of Indians into East Africa—had taken place. Practically, Zanzibar was considered by us as being in the position of a vassal state. Latterly the Germans had taken the position that they had a full right to influence the Sultan of Zanzibar, and had even counselled his removal. Movements of that kind were certainly deserving of much more attention than they received. There was one peculiarity in the proceedings of the German statesmen at the present moment; instead of proceeding on the old lines, on what was called the doctrine of discovery, they set up a new line, and new doctrines. Had he time, it might be well to mention the mode in which they had altered the whole maritime policy with regard to the right of discovery. Instead of the international law on that subject being based on a maritime policy, as it used to be, the Germans introduced what might be called a military policy, and they denied the right of discovery strengthened by naval visitation, and by practical maritime possession, and set up a kind of military policy. They insisted, in the beginning of this crusade as it might be called, that a power demanding sovereignty, or superiority in right of discovery, should place a garrison on the island, and should keep its flag hoisted, and maintain a civil government of its own. Therefore it became of considerable importance to watch the movements of the Germans in East Africa. Formerly, German merchants were contented with working in our grounds under our protection, because a German, in most parts of the world, found it much more convenient to be under English than German protection. Under English protection, the German was free to carry on his trade as he liked, but under German protection there was a policeman at his back, and he knew by experience what that meant. He might take an opportunity of canvassing one portion of the paper, that with regard to the former occupation of Africa by the various races. He would remind Mr. Johnston of the doctrine with which he believed he was conversant, and which was now occupying the attention of men of science, and that was the possibility that Asia was not the sole centre of a population of migration, but that Africa may have been a centre of population, not only for dark races, but also, in the case of the mountain regions, for light African races. He merely mentioned this subject, because the more important part of the paper was that which referred to the commerce of East Africa, and the expansion which had taken place.

Mr. MARTIN WOOD said as the paper went back to pre-historic times it was impossible for him to deal with that part of it, but perhaps he might be permitted to mention one or two points. To those who had lived in Bombay the native firms, the names of places, and many particulars comprised in the paper were as familiar as household words. Reference was made in the paper to the British occupation of Mombsa, and to the proceedings leading to that annexation being revoked by the Governor of Bombay; and that intervention, no doubt, was similar to many others which were often carried out in those times by captains in the Indian Navy with great success and discretion in arranging affairs on the coast of the Red Sea. This intervention often resulted in conciliating and settling many of the districts in a way which perhaps no other policy could have done. Mr. Johnston stated that, unfortunately, the arrangement made by Captain Vidal was set aside by the Governor of Bombay in deference to our alliance with the Imam of Maskat; but probably this was the right policy, for very often more was done by the aid of our native allies than by direct colonisation. With regard to the influx of immigration which Mr. Johnston spoke of as having occurred in Sir John Kirk's time, he thought it must have gone on steadily in previous years. Sir John Kirk, when he went to that country, had to learn all about the coast; but it should not be forgotten that there were men before him who prepared the way. He was very glad that Mr. Johnston had referred, although only in a very mild way, to the German intrusion on the coast; and he had been glad to hear Mr. Hyde Clarke's remarks on that subject. This was no mere English view of the destructive proceedings on the hitherto prosperous coast districts of Eastern Africa. In the *Diplomatic Fly Sheets*, just issued, there was a very complete history of the German colonisation movement, now followed by bombardment and ruin of all the traders on the coast. This exposition was by a German writer, Dr. Eugene Oswald. Although the word "colonisation" was used very loudly, it was simply a misnomer. He (Mr. Wood) should term this downright filibustering of the worst kind, and he feared that our Foreign-office had given an undue opening for that interference; but now that the mischief had been seen, it was to be hoped that something would be done to remedy it. As to the Khojas, the whole history of them was brought out in a notable trial which took place in Bombay in November, 1868.

Mr. Johnston spoke of the Khojas generally as being under the influence of their spiritual chief, and as being opposed to all education and progress. This was true generally; but the trial to which he referred showed that the large majority of Khojas were not under that tutelage, but were friends to education and improvement, as many other British Indians were. While the paper was being read, it occurred to him that an essay by the late Sir Bartle Frere, published in *Macmillan's Magazine* in 1862 or 1863, having the title of "The Indian Epicureans," giving an account of African immigration, and the influence of the Arabs from Maskat from the earliest time, might very well be read with the present paper, it forming an interesting link in the subject which they were that evening discussing.

Sir OWEN T. BURNE, K.C.S.I., thought they ought all to be very much obliged to Mr. Johnston for his interesting paper. It was the custom in this country to depreciate ourselves, but his own impression was that Africa, through our means, was going to have a great future. He was of opinion that there was a mysterious link between England and Africa, notwithstanding many mistakes on our part, and we should congratulate ourselves on the fact that, as 100 years ago India fell to the East India Company, they were not far from getting the best part of Africa through the East African Company which was now formed. This would go a long way to repair the many blunders which England had made during the last few years in its African policy. Consequently, he thought that any gentleman who came and instructed them on the East African question was entitled to their warm thanks.

The CHAIRMAN observed, with regard to the remarks of Mr. Hyde Clarke on the coolies in Natal, that they were not the only coolies in what might be considered South-Eastern Africa, for there were something like 250,000 in Mauritius, and in Réunion there had been very lately about 40,000 under the French. There was, in fact, a very large and strong Indian element of about half a million Indians about the coast of Africa, if they were not actually on it. In other words, there was a very great *rapprochement* between India and the African coast; though it was clear that, as a class, the coolies were not to be compared with the merchants. He hoped when Mr. Johnston returned to Africa he would not fall into the great mistake which had been made by the French and others, of registering Indians according to their nationalities instead of their caste or religion. When in Réunion, he found all classified as Malabars and Calcuttas; he did not believe the authorities knew a Mohammedan from a Hindu. This was one great cause of the ill-treatment of which they complained. It was most important that a man's religion should be ascertained, and that he should be known by his caste as well as by his nationality. The question of Africa—more especially of Eastern Africa—had now become of paramount import, and the relation of Mr. Johnston's experience herein is not only interesting in itself, but holds out promise for the future. The mine of knowledge which he had already opened would no doubt give a continuous yield of riches, and if health be spared we may look for many valuable instalments of intelligence from her Majesty's Consul for the Portuguese East African Settlements. In alluding to the Indian subjects entrusted to his care, he had made a step in the right direction. It is far more satisfactory to be told there are 1,000 Hindus, of whom the majority are Banyans or Wanias of the Bhattia division, 100 Parsis, and some 6,000 Mohammedans, of whom two-thirds are Khojas, and one-third Boras and Memans, than that there are so many Sindis, and so many Kutchis and Gujarâtis. The reader of the paper had gone somewhat minutely into description of the *Khwajus*, or *Khojas*, so that he need say no more about them, except that the word is Persian, not Arabic, and means a man of respectable position, that is, substantially well off. *Meman* is a corruption from Momin, or "Believer." The term was given, perhaps, to converts from Hinduism; Burton thinks they originated from Kuch. As to the *Boras*, Dr. Wilson refers the word to Sanskrit, though some pretend to have found for it an Arabic derivation. Colonel Yule divides them into two classes:—*Shías*, townspeople from Surat, Burhampur, and Ujain, originally of Guzerat, akin to the Ismaïliya, claiming as their head one Yakub, who emigrated from Egypt, and landed at Cambay in A.D. 1137. The chief seat of doctrine, however, was in Yemen, up to the period of the Turkish conquest, when a large exodus took place to India. They attach to their pontiff (mulla) a divine character. There are many sectarian subdivisions. Among the *Boras* also are *Sumis*, said to be of Hindu descent. In conclusion he proposed a vote of thanks to Mr. Johnston for his excellent paper, wishing him God-speed, and all good wishes for the work he was about to undertake.

The resolution was carried unanimously.

Mr. JOHNSTON said he was extremely obliged to the meeting for the sympathetic way in which he had been received, and he was very much interested in the remarks which had been made about Natal. His reason for not touching upon this subject was that he had never been there, and he thought it was as well not to treat upon subjects that had not come under one's personal observation. With regard to the complaint that British Indians were rather ousting Englishmen and others from certain trades in the colonies, he was not in the least affected by this; in fact, he did not care a straw about it, for wherever he was, he was quite indifferent whether the man was a Hindu or anything else as long he was a British subject. If the Indians had ousted Englishmen it showed that they were better men, and the

best man should always win. Some valuable remarks had been made about the Khojas in Bombay, and the celebrated suit brought against the Aga Khan, in 1868. He had done his best to get up the information on this subject, having read through the proceedings of the trial, though perhaps he might not have thoroughly digested the issues involved. With regard to the chairman's remarks, he did not hesitate to accept his designation of the word "Khoja."

Mr. HYDE CLARKE writes:—In his reply last night Mr. Johnston made a remark on an observation of mine, which should not pass without comment. He said very naturally that his duty was to assist all under his charge. This does not, however, touch the point of the displacement of English storekeepers in Natal by Indian shopkeepers, for there is no parity. Ten Englishmen, members of the English-speaking community, are of more value for the civilisation and advancement of Africa than one thousand Indians, speaking Cutchi or Guzarati. In fact Natal, in comparison with Kilwa or Mombasa, speaks for itself. If we are to advance Indians or other races, it must be by raising them to the higher—the English standard—and not by depressing the English to a lower standard. There is a tendency, however, in the official mind in India to act on the latter course. They choose to forget that our empire in India was begun by English citizens in the English East India Company, that their special status was recognised by the establishment of the Bombay Court and the Court of Calcutta, and that our people have not lost their rights of citizenship. The protected populations have only acquired such prerogatives as has been acquired from us. I use the word English advisedly, because it defines and emphasises the situations under consideration, and because we are too apt to forget our own history, rights, and traditions, and to allow ourselves to be ousted from the fruits of our labours.

FOREIGN & COLONIAL SECTION.

Tuesday, January 29, 1889; Sir OWEN T. BURNE, K.C.S.I., Vice-President of the Society, in the chair.

The CHAIRMAN, in introducing Mr. Goad, made a reference to his past career, to the effect that it was now some fifteen years since he landed in America, and became a member of the United States Engineering Corps. He was at once sent on exploring expeditions into the far West, and spent five years amongst the Redskins, undergoing great dangers and privations, whilst doing valuable work for his Government; he travelled many thousand miles, and on two occasions narrowly escaped with his life from hostile Indians; he ascended, also, some of the highest peaks of the Rocky Mountains and the Sierra Nevada ranges, at one time going over some 4,000 miles of ground in six months. Since then the United States had employed him in important mining explorations in America, and he was going to narrate the results of his personal observations in the district of Colorado.

The paper read was—

GOLD AND SILVER MINING IN THE ROCKY MOUNTAINS OF COLORADO.

By THOMAS WILLIAM GOAD.

From pre-historic times, and through the past ages, gold-washing and the search for precious metals, have ever exerted a fascination over human beings, who undergo privations and hardships that they would never endure for other objects. Labours in this field in the Rocky Mountain region are surrounded with hardship and fatigue. Now and then, scarcity of supplies, and danger from hostile Indians, fall to the lot of those who undertake the task of exploration, and when more light has been thrown upon this subject, there will come a truer appreciation of what is comprehended by leaving the highways to search out the precious metals at almost inaccessible altitudes, and across arid plains and sandy deserts, stretching in endless configuration from the base of the Rockies, westward to the Pacific Ocean.

The far West owes a large portion of its development to the adventurous pioneer, and to him belongs most of the credit for unravelling the mysteries of the earth's crust, and wresting the hidden treasures held within its grasp. The scientific explorer has his complement of men, ammunition, provisions, instruments, and beasts of burden, to start him on his way; but not so with the "prospector," for the latter's possessions consist of a blanket, some coffee and flour, a frying-pan, and a small Mexican mule, or burro, to transport all his worldly goods and belongings. The inevitable pick and shovel, and perhaps a blow-pipe for testing the rocks, are his only tools; and with this "outfit" he cheerfully bids good-bye to his comrades, expecting to meet all sorts of dangers, and to overcome, by his indomitable will, all obstacles. The prospector, as a rule, is a practical mineralogist and geologist, competent to tell the mineral-bearing rocks from their general appearance and character.

The finding of gold and silver in the far West by the pioneers has made the young Republic famous, and the building up of the cities, and rapid development of the settlements has attracted the attention of political economists all over the world. A few years have wrought marvellous changes in the heart of the Rockies, and we find now towns suggesting but the labour of a day with all the wealth and activity of the most advanced civilisation.

Gold is found in the Archæn, and in the eruptive rocks of the Secondary age. In the sedimentary formations it is comparatively rare in the limestone beds, but is not infrequent in siliceous beds. Silver is also found in these rocks. By far the largest portion of gold is derived from pyrites and galena, and their decomposition products, and constitute the source from which it is derived. The principal source of silver is argentiferous galena, while argentiferous grey copper is the next most important silver-bearing mineral. Placer deposits are generally confined to the valley bottoms among high mountain regions. In these deposits of gravel, the gold has been mechanically separated and disseminated throughout the beds. The gold is brought down from the mountain sides, and comes from the breaking up of the older rocks by atmospheric agencies, its origin being the gold quartz veins higher up than the placer beds.

It is intended in this paper to make only a general statement describing the Rocky Mountain mining country, so that those who are unfamiliar with its topography and mineral resources may form some idea concerning them. The area is very large, and it will be many decades before the investigations being made can tell us of the distribution and extent of its precious ores.

From the plains to the eastern base of the mountains the rise is gradual. The piñon growth marks the lower hills, the pine-covered country a greater altitude, the timber extending to a height of 11,000 feet to the heavily broken and bold crests of the serrated range. The Rocky Mountains have a north and south trend, with spurs and basins between them, giving an idea of numerous distinct ranges, and offering a vista of an endless succession of mountain peaks beyond each other. The irregular spurs have, usually, on the one side precipitous walls, and on the other smooth faces with cone-shaped apices of eruptive rocks. From the testimony of S. F. Emmons, United States Geologist, we learn that the rocks intimately connected with the ore depositions are probably of the secondary age or Mesozoic. The geology shows that at the close of the Archæn era, or in the Cambrian Ocean, a large area formed a rocky island, with a number of minor islands adjacent to it. During the whole of the Paleozoic and Mesozoic era continuous sedimentation went on in the seas surrounding these islands, of material derived from their abrasion. The geological record, as far as it has been studied at the present day, gives evidence of a great disturbance during this period. Towards the close of the Cretaceous period, at the time of the formation of the coal beds, the seas became shallowed, owing to a general elevation of land. During this time, and possibly earlier, immense masses of eruptive rock were forced up through the already deposited sediments; but, unlike the lava flows of modern days, however, these molten masses were not as a rule spread on the surface of the rocks, but congealed before they reached it, either in large masses, in dikes, or in sheets spread out between the beds. At some time after the close of the Cretaceous period a general dynamic movement took place, by which the existing mountain ranges or islands were crushed together, broken, and elevated, and considerable areas of the adjoining sea bed were lifted up. During the Tertiary era, and subsequent to it, eruptions of igneous rock occurred, generally following the lines of the earlier eruptions, but, unlike those, spreading out on the actual surface of the land, and in some cases beneath the sea. While the general form of the mountain area was determined in the very earliest geological times, it is only since the Tertiary era, and in a general measure by erosion subsequent to the Glacial period, that the present sculpturing of the mountain forms and carving of the valleys have taken place.

The theories as to the time of the deposition of the ores opens such a wide field for discussion that it may perhaps be better not to deal with that question, and to confine ourselves to separate interesting cases, involving existing conditions, and giving as much as possible the characteristics of gold and silver mining in Colorado. The gold fissure veins of the Holy Cross district, the auriferous grave deposits of the Arkansas Valley, and the silver veins of the great carbonate camp of Leadville, may be taken as examples to show the inexhaustible wealth of a barely "scratched" area.

Gold Veins.

The most important, perhaps, of the true gold fissure-veins of the Holy Cross district were discovered in 1880 by a prospector named Harry West, to whose untiring energy is principally due the prominence to which this district owes its present position. The story of the "find" resembles that of many other similar discoveries, and need not be told here. The Holy Cross Mountain has its major axis north and south, and rises to an elevation of 14,176 feet above the level of the sea. It is located in north latitude 39° 30′, and west longitude 106° 30′ west from Greenwich. The dynamic action, as a result of pressure and tangential contraction, produced the elevation of the Holy Cross spur of the Rocky Mountains. The formation, or country rock, is granite, the uplift and dislocation being accompanied by a great number of faults and fissures, and the spur has been fractured by rents in many directions, which have been filled by veins and constitute the mining district. The ore bodies occupy these true fissures (crevices cutting across the stratification planes ?), and are strongly well-defined veins, with an average width of six feet between walls.

The veins are collections of mineral matter, closely related, but differing to a great extent in character from, the enclosing country rock. They are vertical, and have a strike north-east and south-west. The gouge is a layer of clay or mud seam lining both walls of the veins. Where the veins appear on the surface, or at the outcrop, they are composed of rusty quartz, forming troughs or depressions on the side of the mountain, and are traceable for a long distance over the summits of the spur. Above timber line the mountain sides are of cragged rock, here and there hidden by rock slides, which sometimes confines the prospector in his operations by covering a certain amount of the hidden treasure from view. The veins are in an oxidized condition, the gold contained in them being free, easily treated, and in sufficient quantities to pay well for its separation from the matrix or waste rock. Their limiting depth for mining purposes can never be reached. These fissures, from their continuity and comparative regularity, can be cited as characteristic of the true fissures found all through the mining belts of the Rocky Mountains. The veins pinch and widen, but the cavities and chimneys of ore that give rise to bonanzas are unquestionably there. The gold is distributed in stringers or large masses. The gangue material is in the majority, and the precious metal in chûtes. When the vein is stated to be six feet wide, it is not to be supposed that there are six feet of solid mineral, but that that is the width of the matrix, while the ore body is only a few inches wide. The crevice matter consists of decomposed granite, feldspar, porphyry and quartz. The pyrites is altogether oxidized into rusty iron, and has liberated the gold which is entangled in the cells of the honeycombed quartz.

Developments are made by open cuts, longitudinal tunnels, cross-cut tunnels, shafts and winzes. The process of winning the gold from fissures may be briefly stated as follows:—The ore is broken in the levels, stopes, or raises, and brought to the surfaces either by machinery or manual labour. Thence it is taken to the ore bins above the stamp mills, so that the force of gravity may be used in handling the heavy material. Usually, rock-breakers prepare the ore for the stamps, and the delivery to the stamps is regulated in size by the nature of the ore. The stamps reduce the ore to a pulp, and, with the assistance of water, it goes on to a succession of heavily-silvered coppers or plates, which have an oscillatory motion, and this is where the heaviest per-centage of gold is caught. Concentrators also are used in conjunction with the plates, to save the balance of the material containing the gold.

Gold-beds.

In 1859, the auriferous gravel deposits of the Arkansas Valley were discovered, and, in 1860, more than 10,000 people entered this section. From 1859 to 1865, upwards of one million sterling was produced. The mines at that time were considered of great value, as all the necessary supplies for working them were brought across the plains for a distance of over 1,000 miles by beasts of burden, at an enormous cost. The approximate latitude of the auriferous deposits is in 39° 15′, longitude 106° 30′, at an altitude of 9,500 feet. The deposit lies in between the main range and a spur of it known as the Park range, and is in the shape of an amphitheatre, between closely-approaching walls of rock, where the river passes through. Both sides of the valley rise in steps, or *mésas*, and present a series of successive table-lands, caused by circumdenudation up to the foot-hills of the mountains. The average width of the valley is about six miles. The detritus of granite and quartz-rock gouged out of the mountains during the

Glacial period, left great basins in which are the Twin Lakes, two of the largest sheets of water in Colorado. The *débris* being carried beyond, presumably forced the river out of its course and filled the ancient channel with the gravel ridges or large terminal moraines that exist. The granitic mass enclosing this valley is seamed with small veins of gold quartz, and is the source from which the gold comes. Among the boulders and sand the gold occurs in a metallic form in small particles, nuggets, and fine dust, the latter being hardly perceptible to the naked eye. The gold is not disseminated uniformly through the beds, but by its gravity has found its way in the greatest quantities near the bed rock, and where this is undulating, or turned up on edge, rich pockets of gold may be encountered, either on the "bars" or in the depressions. Frequently associated with the gold a rusty sand is found, containing pebbles of magnetite iron, or black sand, and where this occurs the miner considers he has a good "prospect." The Twin Lakes Syndicate, of London, derive their main water supply for working a part of these placers from a stream at a point six miles distant, and at great cost have brought the water at an elevation of 200 feet above their gravel beds, securing a hydrostatic pressure of great value.

The requisites to profitable placer mining are, a sufficient quantity of pay dirt, a plentiful supply of water, and a dump or place for the material removed. The old process of washing gold was in principle the same as it is now. Then a wide shallow bowl called a "batea" was used. The "batea" received the gravel and water, and was shaken up until all the coarser material had been removed by hand, leaving the gold and fine sand in the bottom. This plan was improved upon by the Long Tom, a box about 12 feet long and 18 inches wide, with an incline of one inch per foot. In the bottom was placed a perforated sheet-iron plate, over which the material was carried by water, the fine sand and gold passing through the holes, the coarser rocks and pebbles being shovelled away. Following on this came ditch building, sluicing, &c. A sluice is a series of wood boxes joined together, making a flume, and is usually placed on the bed-rock, having a sufficient grade to carry away the detritus held in suspension by the water. In the bottom are arranged blocks of wood about four inches high and four inches across, and about one inch apart. Between these spaces quicksilver is dropped, and the gold is caught by amalgamating with it. When a sufficient quantity of gravel has been washed the stream is turned off, and, commencing from the head, the riffle blocks are taken up, the amalgam being swept together and collected in buckets. The first use of hydraulics was made in California in 1852 by conducting the water under pressure through a raw-hide hose and wooden nozzle. This was improved by canvas hose and the goose neck, resulting in the present system of iron piping and the "giant" nozzle. Where eight men were only able to "pan" in the neighbourhood of eight or nine cubic yards per diem, the same number of men by the use of the "giant" can now wash over 500 cubic yards in the same time. A three-inch giant nozzle, delivering a stream of water 150 feet a second, will develop a force at its mouth of over 34 tons.

The banks of the Twin Lakes gravel deposit show a depth of from 15 feet to 300 feet, and it may be safely said that two-thirds of this gravel has an average value of 1s. 3d. per cubic yard. In California, gravel that will average 4d. per cubic yard is considered "pay dirt." The requirements to successful working in these mines are present, and money expended judiciously in improvements cannot fail, under proper management, to give large returns on the outlay.

Silver Mines.

The history of Leadville, the great carbonate camp, is one that will ever be remembered, on account of the extraordinary changes made within three or four years—from a wild scene of frontier life, to that of complete civilisation. Indirectly discovered in 1877, by placer miners, who could not get rid of the heavy dirt, which prevented sluicing, and which proved to be argentiferous lead ore, its production counts up in scores of millions. The area from which this wealth has been produced covers less than ten miles square of hill-country, varying in elevation from 10,000 to 12,000 feet. From 1877 to 1881, upwards of 40,000 people covered the hills, leaving a population to-day of about 17,000, of which 60 per cent. are actually engaged in mining.

The first smelter was put up in 1877, since which time there have been erected more than 14 others, handling annually over £3,000,000 sterling worth of argentiferous lead bullion. Three railways give shipping facilities between the Atlantic and Pacific coasts.

The erection of hotels, theatres, public build-

ings of brick, together with tramways, gas, electric lighting, telephone lines, &c., closely followed upon the first "strike" of rich ore. The "Cloud City" is located on the side of a lake-like basin, between two ranges of mountains, the terrace-shaped plateaus forming the different shore-lines of a subsiding inland sea. The hills have a basis of granite, covered by Paleozoic formations, and by enormous intrusive sheets of eruptive porphyries. The ore generally occurs on the limestone horizon, with overlying sheets of porphyry, and is found to replace this stratum, and also to extend into it in larger bodies.

The precious mineral is mainly silver, contained in the carbonates of lead, with oxides of iron and manganese. The most important chûtes of rich ores are found on Fryer, Yankee, Carbonate, Iron, Rock, Printer Boy, and Little Ellen Hills.

On Fryer Hill the ore bodies were irregular, practically horizontal, and with a maximum thickness of ninety feet. Here the ore has entirely replaced the limestone, and lies in the porphyry.

On Carbonate Hill the mineral follows the bedding planes of the limestone with porphyry above. There are two distinct deposits, one above the other, with a vertical interval of approximately 100 feet between them. The dip of the veins into the hill is at an angle of 15° from the horizontal. The ore channel has an average width of about 500 feet, and a maximum thickness of about 50 feet.

The most important shaft on this hill is owned by the Agassiz Mining Company, and has developed a vein forty-three feet thick, at a depth of 663 feet from the surface. Where this shaft intercepts the first vein the ore has apparently entirely replaced the limestone, and is between two porphyries.

Iron Hill much resembles Carbonate Hill in its underground structure, with the exception that no second vein has yet been discovered below the first zone of limestone. In the Silver Cord Mine on this hill developments have shown that the ore extends into the limestone to a great depth from its upper surface.

Other important mines of this type are found on Rock, Yankee, and Printer Boy Hills.

The New Year's Mine, on Little Ellen Hill, has a wide and thick ore chûte, crossing diagonally the dip of the limestone, and is a distinctive ore channel of carbonates carrying gold in appreciable quantities, which enhances the value of these smelting ores to a very considerable extent.

The carbonate ores of Leadville are essentially smelting ones, as they are remarkably pure argentiferous lead ores.

The smelters are built with two floors; the upper floor is on a level with the feeding door to the furnaces, the mixed beds of ore and fluxes being near them. On the lower floor are placed the engines or motive power for running the blowers, electric light, &c. The furnaces are built of brick, and are surrounded by water jackets. Above the lead well is the slag or waste tap. The bullion well is on one side of the furnaces, the metal being ladled out into the moulds prepared to receive it. The dust chambers are below the feeding doors, and are connected with the stack by a covered way of brick, with partitions to catch the "fume dust" as it circulates through the chambers. The charges depend upon the character of the ore, and it would be difficult to give their "make up" as a criterion of the average components of a bed. The fluxes used are limestone and hematite, with coke and charcoal as fuel. The process is as follows:—The furnace is dried gradually by the lighting of a small wood fire inside, and allowed to cool; the crucible is then lined with fire-clay, and the furnace is filled up with fuel to the top of the second floor. When it becomes in an incandescent condition the blast is turned on. Reserve or feeding bullion is next thrown in at the doors, which, when it re-appears in the lead well, indicates that the furnace is ready for the charge.

In addition to the precious metals, the Rocky Mountains contain an inexhaustible supply of other ores, but to describe them in this paper would occupy too much time. There is, however, one other industry almost of as much importance as mining, as it adds to the wealth of the far West, and makes its valleys and plains inhabitable.

The development of its agricultural resources by the reclaiming of arid lands by irrigation, has become a work of great importance. In the British Isles one can hardly appreciate the advantages that are derived from irrigation, but in Colorado, where the rainfall is a limited one, it is of the utmost importance. Since the diversion of streams on prairie and sage-brush lands has proved such a success, large agricultural engineering works are being built every year. In the San Luis Park, situated in the heart of the mining districts of Colorado, and having the largest body of connected arable land in the mountains, we find evidences of so-called barren lands turned into beautiful

gardens. Ten years ago the population in the park numbered a few hundred souls, whereas now the settlers number over 15,000. Canals 40 to 50 miles in length have been built, covering thousands of acres of rich soil with the necessary supply of water to grow all sorts of farm produce and fruits. As an instance of the rapidity with which these waterways are constructed, it may be mentioned that a canal with 50 miles of main channel was built in four or five months, and that it supplies water to over 150,000 acres of land. In Colorado arable land is of little value unless water is assured, but when water can be had, the land becomes worth ten times its former price. The water itself has a commercial value when in the shape of a water right, which is a perpetual claim upon a canal for a certain amount of water each year, throughout the growing season. All through the San Luis Park, low and picturesque houses meet the eye, with extensive orchards of fruit and kitchen gardens surrounding them, and are examples of how the reclaiming of land by irrigation, has made a garden out of a desert. Strong and rapid streams, filled with trout, pour down the mountain sides, and where they debouch on the prairies the head gates of the canals are constructed. The value of this irrigable land may be better appreciated when it is known that millions of dollars are expended annually outside of the State for farm produce, and that many vegetable and fruit gardens in and about this region net from £50 to £150 per acre per annum. Arable land in the valley, after it is improved, yields with any sort of crop, upwards of one pound per acre.

DISCUSSION.

Mr. Brown thought it would be valuable if we had some information as to the behaviour of the miners, those thousands and tens of thousands who found their way to the mines in search of treasure.

Mr. Warnford Lock said it was so seldom they had the opportunity of seeing a practical mining engineer from Colorado that he should like to ask him one or two technical questions. Mr. Goad mentioned that there was a great deal of alkali in the soil; and he should like to know if this alkali, when it got dissolved in the sluicing water, interfered with amalgamation of the gold by the mercury. Miners knew that unless the mercury was clean, and the gold fairly clean, amalgamation was difficult. It was impossible, for instance, to use the mine water in a mill. Another point was that, owing to the decomposition of the iron pyrites in the vein stuff, there was a quantity of oxide of iron produced; in some regions he believed this actually coated the gold grains so as to interfere with the amalgamation. He should like to know if this happened in Colorado, and if so, what had been found the best way of dealing with the difficulty. Judging from the amount of snow on the hills, the cold must be severe for a considerable time, and the action of mercury on gold was much reduced as the temperature decreased, so that he should imagine that working would only be possible during a portion of the year; besides which, the water supply would be much diminished by the frost. The veins, which outcropped as depressions—contrary to the usual experience—were, he supposed, only decomposed to a small depth, below which the pyrites would occur as usually found; but Mr. Goad had said nothing about the processes used for dealing with the pyrites. If he had any special information on that point, perhaps he would add it to his paper.

Mr. Q. A. McConnell said he was one of the pioneers of Salt Lake City, having been one of the first Gentiles who went there; and in those days alkali was the curse of mining. But the alkali had no effect on the floats; they ran the alkali water over it equally with the best water they could get.

Mr. H. D. Pearsall having spent some years in Colorado. thought Mr. Goad had hardly emphasised enough the rapid way in which the comforts of civilisation were introduced into the newest mining towns. He had laid considerable stress on the dangers and horrors of Indian warfare, which might leave the impression that that was the normal state of affairs in Colorado, which was not at all the case. Those dangers were met by the prospectors and pioneers no doubt, but the moment any minerals were discovered a number of people flocked there, and a town sprung up accompanied by almost all the comforts of European civilisation. In an incredibly short space of time there were first-rate shops, post-office facilities, telegraphs, roads, and manufacturing establishments, so that in a year or two the state of material civilisation was far superior to that of a rural village in England many hundred years old. An extremely small proportion of the mineral wealth had yet been discovered; although the population was considerable, and a large army of able mining engineers was engaged in exploring, the immense extent of the mountains was such that only a very small fraction had yet been explored, and even those parts which had been known longest, still contained an enormous quantity of mineral wealth. People often spoke as if because minerals had not been discovered in a certain district they did not exist there, but very often it was just the contrary. Some years ago he took the trouble to examine the statistics of the various occupations, as given in the United States census, and he found the net result was that mining for the precious metals, instead of being the specu-

lative business people were apt to consider it, was really the most steadily profitable of any. The average production of wealth per man per annum in manufacturing was 720 dollars; in agriculture, 600 dollars; and in mining in Colorado, 960 dollars.

Mr. D. A. LOUIS said he had some experience of mining in Colorado, and although the reader of the interesting paper had confined himself almost exclusively to Leadville and the neighbourhood, there were other parts of that State equally remarkable for their mineral wealth. Gilpin County, for example, was the first district in Colorado where mines were worked and where mills were erected, in Central City the first mining institutions were established, and mines are still successfully worked there, such as the Caliiornia Mine; whilst the Colorado State School of Mines is at Golden. Another district was Clear Creek County, and near Irwin's Peak the mining was rather characteristic and very interesting. The Stevens Mine, for example, was very rich in lead, and was peculiar in this—that its upper workings were at an elevation of nearly 14,000 feet above sea level, and were frozen throughout the year to a deep of 200 feet. In summer you go from boiling hot sun outside into galleries and levels filled with and cut in ice. The water melts on the surface, sinks through fissures into the mine, and there freezes. The moisture of the air, arising from the breath of the miners and the burning candles, also freezes, and it is beautiful to see the frost crystals, deposited all round the interior and on everything, glittering like gems in the dim candle-light. On the whole, Gilpin County and Clear Creek County may perhaps be regarded as the most important gold-producing districts of Colorado.

The CHAIRMAN said he did not intend to take much part in the discussion, for he had not much mining experience except that, like a good many others, he had put gold in the ground, but had not taken much out. At the same time, no one could look back on the past mining history of America without astonishment, for whereas a few generations ago wealth was taken out of the ground in thousands, it was now taken out in millions. In Colorado alone, in one year about £18,000,000 in gold and silver had been taken out of the ground, and he had just been reading a book in which a high authority stated that in thirty-seven years £315,000,000 worth of precious metals had come from that State. Such a country was well worth study and consideration. One gentleman had remarked upon the progress of Colorado. It was quite true that thirty years ago, Leadville and Denver were only composed of a few shanties on prairie lands, which reached from the Missouri river to Utah and California. Now, in consequence of the gold discovery, they were large towns, with cathedrals, churches, banks, schools, broad streets, and public buildings lighted by electricity, and would bear comparison with many towns in Europe. Not only gold and silver but other minerals of value. were found in Colorado, including coal. He, himself, had a small interest in a placer mine at some 9,000 feet elevation, to which Mr. Goad had casually alluded, called the Twin Lakes. It was a property of some sqnare miles, capable of considerable development, and he hoped some day would be recommended by doctors in London as a good health resort. Already Colorado was recommended by London physicians to those who had any tendency to consumption. Mr. Goad had made a reference to irrigation, and he hoped he would push that subject forward as much as possible. In India we had spent 25 millions in irrigation, very much to the benefit of that country. There was nothing like it to improve a tract of land such as Colorado was described to be. He concluded by proposing a vote of thanks to Mr. Goad, which was carried unanimously.

Mr. GOAD, in reply, said the behaviour of the miners, in Colorado especially, was, without exception, very good. They had Cornishmen, Irishmen, Swedes, and nearly every nationality except Chinamen in Leadville, and he always found the men exceptionally intelligent and hardworking. Their work underground seemed to give them time for thought, and most of them were good readers. With regard to the mode in which the metal was deposited, that opened a very wide question. Some came from below, and some from above. In the Leadville district one theory as to the deposits of silver ore was that the porphyry, although it came from below, in its decomposition or precipitation had allowed the silver ores to rest on the limestone beds or replace them. It would take a good deal of time to go into the question of fissure veins, and the filling in of the mineral matter, and he could not attempt to deal with it then. He had only mentioned alkali with reference to the "dry-washer;" he found that when moisture existed in the earth it held the gold and gravel together, so that the blower could not separate it; but alkali in the water had no effect, as far as he knew, on the amalgamation. In placer mining gold was in the metallic form, and sometimes was coated with oxide of iron, in which case it often happened that it floated down the sluice and could not be saved. On the other hand, where there were refractory ores it was difficult by amalgamation to save the gold, because the quicksilver became "sickened," as it was termed; it became pasty, and the gold passed off without being caught. With regard to the working seasons, the fissure veins aud silver veins, the Leadville deposits especially, could be worked throughout the year, but placer mining was limited to the summer months. The Twin Lake placer mine could only be worked for five or six months in the year, on account of the frost. With regard to the decomposition of pyrites, as you went down in the earth the quartz was not oxidised, and did not liberate the gold, but it often happened

that to great depths vein material had been oxidised. Then when it became a refractory ore other treatment was necessary; and he would add to his paper a description of the system adopted in the Rocky Mountains for the treatment of these refractory gold ores. Every one recognised that the Colorado of to-day was not the place he pictured it to be in the early days. Denver was a fine city of 100,000 inhabitants, although when he was there in 1877 there were but 15,000. It was now a beautiful town; he knew no place which had a finer theatre, and it had been made entirely by the finding of the gold and silver. There were portions of the country infested with outlaws and "greasers," as they were called, or Mexicans, who were perhaps worse than the Indians, and there were other portions where it was unsafe for any one having money to travel, unless well armed and with an escort. There were but few Indians in Colorado, but in New Mexico and Utah there were still a good many, and if they had a chance, would think nothing of murdering travellers. He had only taken Leadville, the Holy Cross, and the placer mine at the Twin Lakes as characteristic mines, in order to give a general idea of the country. Of course there was Nevada, Idaho, Wyoming, California, New Mexico, Arizona, and other parts of the United States where mining existed, and he quite recognised that Gilpin and Clear Creek counties were as valuable as those he had mentioned.

EIGHTH ORDINARY MEETING.

Wednesday, January 30th, 1889; J. TRAILL TAYLOR in the chair.

The following candidates were balloted for and duly elected members of the Society:—

Oman, J. Campbell, 2, Parnell-terrace, New Southgate, N.
Riches, James, 6, Great Winchester-street, E.C.
Serre, Charles A., Cordova-road, Grove-road, Mile-end, E.
Shirley, John Rogers, Ridley-park, Delaware County, Pennsylvania, U.S.A.

The following candidates were proposed for election as members of the Society:—

Barton, Thomas, 102, Jermyn-street, S.W.
Bignold, C. A. B., J.P., Norwich.
Britten, William Arthur, 299, Norwood-road, Herne-hill, S.E.
Curry, William Thomas, Chelvey, Backwell, Somerset.
Emerson, P. H., B.A., M.B., 10, Marlborough-crescent, Bedford-park, Chiswick.
Gleed, William, 9, Foyle-road, Westcombe-park, S.E.
Groves, Leonard, 10, Ampthill-square, N.W.
Hands, Alfred John, St. Ronan's, Fairholt-road, Stoke Newington, N.
Ionides, Alexander A., 1, Holland-park, W.
Joerg, J. A., 16, Brunswick-square, W.C., and London International College, Isleworth.
Kemp, John, 46, Cannon-street, E.C.
Mackay, John Charles, Stow Park, Newport, Monmouthshire.
Macpherson, Walter Charles Gordon, St. George's Club, Hanover-square, W., and Allahabad, India.
Morris, Evan, Roseneath, Wrexham.
Richardson, Arthur, Ph.D., 22, Meridian-place, Bristol.
Terry, John, Platt Grange, Boro Green, Sevenoaks, Kent.
Thacker, Samuel George, 22, Montague-street, Russell-square, W.C.
Wainwright, William, Carriage Department, South Eastern Railway, Ashford, Kent.
Wilkin, Colonel Walter H. (Alderman), 47, St. Mary Axe, E.C.
Worthington, Prof. Arthur Mason, 9, Tamar-terrace, Devonport.

The paper read was—

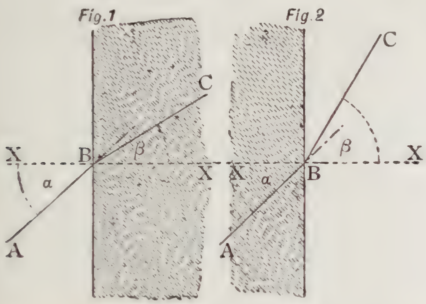
THE CONSTRUCTION OF PHOTOGRAPHIC LENSES.

BY CONRAD BECK.

The paper you have done me the honour to ask me to read to-night will, owing to the extent of the subject, be very incomplete. It is of course, in a single evening, impossible to do more than indicate a few of the main principles that are involved in the construction of photographic lenses; and if in some of my preliminary remarks I weary you by the repetition of matter that "every schoolboy knows," I must ask you to excuse me, as I feel that the only safe way to approach a subject of this kind is entirely *ab initio*.

The theory which has explained the majority of the phenomena of light is that it is produced by vibration in a medium we call ether, which is assumed to permeate everything. Although this theory may be superseded—or more correctly, developed—it is quite sufficiently certain for us to accept its results for the purposes of this paper. The vibration is held to be a wave motion which takes place at right angles to the direction in which the light is moving. The distance between two consecutive crests or hollows of the wave is termed a wave length. This wave length does not depend on the intensity of the light, and for the same coloured ray it is always the same when travelling through the same medium.

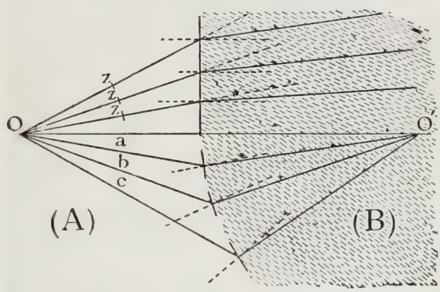
But should this ray pass into another substance of greater density—as, for instance, from air into water—its wave length will be shortened, and will give rise to the phenomena called refraction. Without, however, entering fully into the causes, let us merely examine this fact we call refraction. We can at once see, by the very simplest experiments (as, for instance, placing a stick in water), that the light which comes from an object in a denser medium is bent on its journey, and as rays of light in one medium alone are experimentally proved to move in straight lines, this alteration ef direction or refraction must take place at the surface of the two media. Precisely the same result ensues when light passes from a lighter into a denser medium. But it is observed in the two cases that the direction of the refracted ray is different. In Fig. 1, where



the ray passes from a lighter into a denser medium, it will be noticed that the refracted ray turns towards the perpendicular to the surface which divides the media, whilst when it passes from a denser into a lighter medium it turns away from this perpendicular, or the normal as it is called. We find, by experiment, that if we take the ray which cuts the dividing surface at right angles it will pass direct into the second medium without refraction, and that rays which inpinge on this surface at different angles are refracted to a different extent. It only remains to discover whether there is any law which these refractions follow which can determine at what angle any ray will emerge in a given medium, when entering it for another given medium. It is curious to find that Ptolemy, in the 2nd century, made observations of the angles of incidence at a surface, and their corresponding angles of refraction. Vitello, a Polish mathematician, in the 13th century, did the same, but the law of refraction was not discovered until 1621 or so, by Willebrod Snell. This law (which is established by experiment) states that when we are dealing with two media of different density, the sine of the angle of incidence, divided by the sine of the angle of refraction, is equal to a constant quantity, which is called the index of refraction; and it was also observed that the incident and refracted rays lie in one plane. The angles of incidence and refraction are the angles which the incident and refracted rays make with the normal; thus, in Figs. 1 and 2, the angle of incidence is the angle ABX (α), and the angle of refraction is the angle CBX (β).

Let us now consider light coming from a point O in one medium (A) Fig. 3, say air, and entering another medium (B) which we will suppose denser, say glass. Light will impinge on the dividing surface, which for the first case (upper portion of Fig. 3) we will consider flat,

FIG. 3.



at all angles. Let us first note, as we said before, that the ray which strikes the surface at right angles goes through it without refraction. All other rays will be more or less bent, and the law of refraction shows us that those in which the angles of incidence is greatest have greater refraction in proportion than rays of smaller angles of incidence, for if we differentiate $\frac{\text{Sin } \alpha}{\text{Sin } \beta} = \mu$ we shall see that as the angle of incidence is increased the amount of refraction, or the difference between β and α, is increased much more rapidly. In the second case, suppose instead of a flat surface we take a series of small facets and place them at right angles to each ray, then these rays will all pass through into the glass without refraction; thus, if we have light coming from the centre of a circular surface, it will pass through it without refraction.

Next (Fig. 3, lower portion) let us place our series of facets in such positions that, instead of destroying the refraction of the several rays, we increase it. Let us do

this to such an extent that, instead of having a diverging series of rays, we make them converge towards the axis. Now, by properly arranging our plates we can make the three rays, *a*, *b*, *c*, (Fig. 3, lower portion), converge to the same spot. But since the number of rays is infinite, we shall need to place a series of plates so small as to be merely points. These points will trace a curve, and the form of this curve will be the necessary shape of the dividing surface of the two media, in order to cause a bundle of rays proceeding from a point, O, to converge to some point, O′, in the denser medium.

Now this is just the proposition we have in photography. It is required to converge the light emerging from one point of the object to a single point on the photographic plate; but as a rule the object is at infinity, and light impinges on the surface in a parallel bundle. The practical photographer must not be misled by this word infinity; it is a relative term, and a distance of twenty feet, for instance, when compared with a distance of two or three inches, is practically at infinity, *i.e.*, we can treat all light which starts from such a distance as travelling in parallel rays. Now the curve which would bring parallel rays to one single point is a conic section, and Descartes showed that if lenses could be made whose sections were ellipses or hyperbolas, they would accurately accomplish this. But, alas, all practical men know that it is impossible to make these surfaces true enough for optical work. One true surface we can make, and that is a spherical one, and this is the one which, for want of a better, we are obliged to adopt. To make it clear why a parabolic or elliptical surface cannot be made, I will merely draw your attention to the fact that, in order to grind or polish a lens surface, a tool must be made of the exact shape of the lens required, the lens must then be ground with emery or some other material until the glass assumes precisely the shape of the tool, and in order to accomplish this it is essential that the glass be moved over the tool in several directions, and that it is at the same time touching the tool over its whole surface during the operation. In practice it is found that the more irregular the motion within certain limits, the more likely the surface of the glass is to be ground equally all over. As an example, let us suppose we wish to make a lens of elliptical shape, the only way in which the glass can be moved in the tool while it remains in contact over its whole surface is by its being revolved on the axis of the ellipse. It is evident that if this be done, as the periphery moves more rapidly than the apex, more will be ground off the edge than the centre, and a true curve cannot be obtained.

What, now, is the effect of using a spherical surface? The rays no longer all meet at one point, and the larger the surface of the sphere we are considering, the more difference is there between the points to which they converge. The error which thus arises—due to the fact that it is necessary for us to use spherical surfaces—is called spherical aberration, and I propose to show what are the devices by which we reduce it to a minimum.

There are only two cases in which it is possible for us to obtain no aberration for light passing through one single surface, and both of these are useless for photographic purposes. The first case we have already mentioned, when the object is placed in the centre of a sphere, but, as we saw, this gave no refraction; the second case is when the distance of the object from the centre of the sphere is equal to a certain quantity, viz., the refractive index multiplied by the radius of the spherical surface. For photographic lenses the radiant point is almost always at a great distance, and its rays being, therefore, parallel, cannot enter any surface as if they emerged from a point comparatively near to the centre of the spherical surface, as this would be.

I shall not weary you by going through the mathematical steps which determine the exact amount of aberration for rays due to refraction through a single surface, but the amount is given by the equation—

$$\Delta f = \frac{\mu - 1}{\mu^3} (\rho + D)^2 \left\{ \rho + (\mu + 1) D \right\} \times \frac{y^2}{2}$$

Where f is the reciprocal of the distance of the point to which the rays converge from the refracting surface, ρ is the curvature of the surface, y the semi-aperture, D the reciprocal of the distance of the radiant point from the surface, and μ the index of refraction. In dealing with this equation we must not take the absolute aberration, but take it with reference to the focus, and there is not time to-night to discuss the way in which it varies.

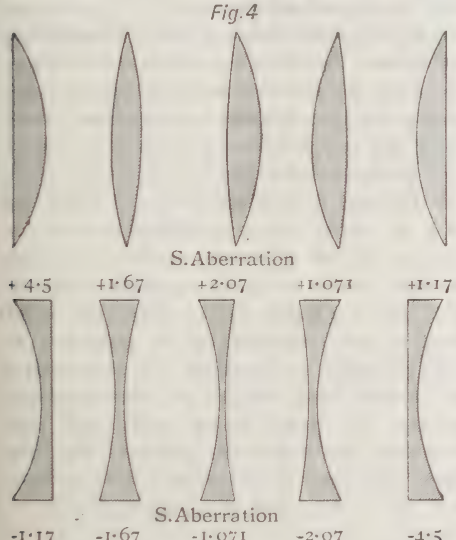
I have previously mentioned that in order to bring a bundle of parallel rays to a point, we require an ellipse or hyperbola; it should be the former when the rays enter a denser from a lighter medium. It is interesting in this connection to note that the most perfect projection lens in existence, the human eye, has

for its first surface (the cornea) a portion of an ellipsoid, whose section would thus be elliptical.

We assume, therefore, that the nearer a surface tends towards the elliptical form, the less aberration it will possess, and it is evident that a convex surface is nearer to an elliptical form than a flat surface, and will therefore give less aberration, whilst, at the same time, it has greater refracting power. And we can further see that the nearer we make this convex surface approach the given ellipse (which is determined by the refractive index) the more we destroy aberration. If now we take two refracting surfaces and form what we call a lens, we at once ask ourselves, Can we not, by properly combining the two curves, destroy aberration entirely, and yet leave some refraction, for we see that the two do not vary in proportion? We find that we can make lenses of the same refractive power, but with widely differing aberration; but in spite of this, we cannot entirely destroy it, with the kinds of glass that we now possess. We should require a material with a refractive index of at least 4, the possibility of discovering which is altogether beyond our most sanguine hopes.

It is therefore impossible to entirely correct aberration in one lens. We can, however, largely modify it. I have made a diagram showing the relative amounts of aberration

Fig. 4



which arise from lenses of various shapest and you will see that the lens with the greates, amount of aberration possesses four times that of the best form. As a general rule, we can remember that when parallel rays enter from a less refractive medium—say air—into a denser medium—such as glass—the more curved the surface turned towards the parallel rays, the less the aberration; the flatter the curve, or the nearer it approaches a flat surface, the greater the aberration.

I have placed at the top of this diagram a series of convex lenses, all of the same focus, giving their aberrations, and below them a series of concave lenses, also of the same focus (only negative), giving their aberrations. If, now, we take a convex lens and place it next to a concave lens, with just the same relative aberration, we shall neutralise the aberration, but, since the focus is the same, the refracting power will also be destroyed, and the compound lens will have no power to affect light passing through it But suppose we take a convex lens with the smallest amount of aberration, and combine it with a concave lens of the largest quantity of aberration, although we get the refraction neutralised, we shall get the aberration far more than corrected, and can reduce the focus of the concave lens, and with the focus the aberration, which is dependent on the focus, to such an extent that the aberration is corrected, and we shall then have left a considerable amount of refracting power, although, of course, not so large an amount as in a single convex lens.

Let us then see to what conclusion we have arrived. We have found that light is bent on entering a medium of different density, that we can nearly bring this to a point, but not wholly, by a single spherical surface. That a lens will, to a certain extent, correct the error thus formed, but not altogether, but that a combination of two lenses will completely do so.

We have hitherto treated light as if it were caused by a single vibration of the material we call ether, this vibration having always one wave length which is only altered when the light passes from one medium into another of different density. This, however, is not the actual fact, though in order to explain spherical aberration it was convenient to assume that such was the case.

The effect which gives rise to the sensation of white light in our eyes is supposed to be produced by the combination of a large series of vibrations all acting together on the retina of the eye. If we consider a vibrating ray emerging from the sun or some other powerful light-giving source, we shall find that it consists not of one vibration with a single wave length, but of a great number all travelling

together at the same rate, and differing only in their wave length. On more close examination of this ray we shall find that the vibrations consist of some with a long wave length, others with a slightly shorter wave length, others again still shorter, until we have vibrations with exceedingly short waves. In fact, the complete ray consists of an ascending series of vibrations, each having a slightly shorter wave length than the last, and all travelling together.

It is interesting now to see in what ways these various vibrations affect our different senses. If we isolate from a complete ray the waves only that have very long wave lengths we shall find that no effect of light is produced on our eyes; but if we place a thermometer in the path of these rays, we shall observe that these long wave-length vibrations have heating power. Let us now isolate a portion of vibrations with rather shorter wave lengths; we shall find that the effect of heat is still produced, but that our eyes are also affected by these rays, and the result obtained is that we see what we call red light. Isolating again another portion of the vibrations with still shorter wave length, the effect they produce on the eye is again light, but of a different colour—yellow. The next vibrations produce the colours to the eye of orange, green, blue, and violet, in the order of the spectrum, until at last we come to a point where no further effect of light is produced. The vibrations do not, however, cease here. There are vibrations with still shorter wave lengths than those which cause light, and these, together with the green, blue, and violet vibrations are the waves which affect the photographic salts of silver.

One must not suppose that there is any radical difference between these rays beyond the difference in their wave length. They affect our different senses in different ways. The vibrations that are beyond the visible end of the spectrum would give rise to light, except that our eyes are not delicate enough to see them. We have every reason to believe that they are visible to some of the smaller animalculæ. The same applies to the heat rays, and if our eyes were but sensitive to them, we can conceive it possible that we should have no need to ask our companions in the room if they found it too warm, we should see if they did so.

Let us now retrace our steps. You will remember that refraction is due to the fact that the wave length of light is altered by passing from one medium into another of different density. This light, however, does not consist of one vibration but of a series of vibrations, each with a different wave length, and it is a fact proved by experiment, and accounted for by theory, that these vibrations have their wave lengths altered in passing from a rare into a denser medium in a different manner.

We have shown that it is possible to construct an optical system which will refract a bundle of parallel rays to a single point, but, in doing so we have assumed that the light was caused by vibrations of the same length, namely, that it was of the same colour. The rays, however, have not the same wave length.

This defect, namely, that a bundle of white light entering a lens does not come to the one point owing to the fact that light of different colours is refracted to different extents is called chromatic aberration, and the correction of this error is one of the most important of the optician's duties. The amount of the difference between the refraction of the extreme colours when passing through a glass is called the "dispersion" of that glass. Glasses can be made which have different refracting powers, and with the difference of the refracting power the dispersion generally varies. If the dispersion of these glasses were always in the same proportion to their refraction, it would be impossible to correct for this aberration, for suppose we have a convex lens which has a dispersion one-tenth that of its refracting power, by which I mean that if it brings the violet portion of a bundle of parallel rays to a point nine inches from the lens, it will bring the red portion to a point ten inches from the lens, and suppose we place a concave lens in front of this convex lens, which will give us exactly the same difference in the refraction of the different colours (but being concave it will be in an opposite direction), then, if the amount of the dispersion of this glass is also one-tenth of its refraction we shall, in order to neutralise the dispersion of the convex lens, require a concave lens of exactly the same focus, and shall also neutralise the refracting power of the combined pair, and the compound lens no more acts as a lens, but as a parallel plate of glass.

It is found, however, that glasses can be made which have different degrees of dispersion in comparison with their refracting power. In general the more highly refractive glasses have a higher proportional dispersion. We might perhaps find, for instance, that a glass

had a dispersion equal to one-fifth of its refraction, instead of one-tenth part.

If, then, we make our convex lens of a glass that has a dispersion only one-tenth of its refracting power, and make our concave lens from the glass which has the higher dispersion equal to one-fifth of its refraction, we shall find that the latter will only require to be half as powerful in order to correct the dispersion of the original lens, and although it will have neutralised by one half the original refraction, there will still be left remaining a power equal to half that of the convex lens. Thus, for the correction of chromatic aberration, it is important to note that the only essential condition is that the foci of the two lenses should be proportional to the relative dispersion. If one glass has a dispersion of one-tenth of its refraction, and the second glass has a dispersion one-fifth of its refraction, and if we make a positive or magnifying lens out of the first glass, and a negative or diminishing lens out of the second glass, provided the first lens has a refracting power double that of the second, the chromatic aberration will be corrected, no matter what the shape of the lenses, and it is evident that by altering the curves of the lens, but always having the same balance between the two curves, either of the lenses may be made in many different shapes, and yet give the focus required. Thus the correction for achromatism depends not upon the shape of the lens but on the foci of the two component lenses, while, as we saw before, the correction for spherical aberration depends not upon the foci of the lenses but upon their relative shapes. There is therefore no difficulty in correcting for both spherical and chromatic aberration in the same pair of lenses.

The formula, the conditions of which must be fulfilled in order to obtain an achromatic pair of lenses, is a simple one, and runs as follows:—

FORMULA A.

$$\frac{\phi_1}{\phi_2} = \frac{\left(\frac{\mu - 1}{\Delta\mu}\right)_1}{\left(\frac{\mu - 1}{\Delta\mu}\right)_2}$$

When ϕ_1 ϕ_2 are the refracting powers of the two lenses, and $\left(\frac{\mu-1}{\Delta n}\right)_1$ $\left(\frac{\mu-1}{\Delta n}\right)_2$ the relative dispersions of the two glasses in use. Let us take an example where the relative dispersions in two glasses are 43·3 and 36· respectively, the equation then becomes—

$$\frac{\phi_1}{\phi_2} = \frac{36}{43{\cdot}3} \text{ or } \phi_1 = {\cdot}87\,\phi_2$$

From this it will be seen that, by assuming the focus of one lens, we are able to find the focus that the correcting lens must have. I think it would be as well to mention that, owing to the fact that the dispersion of a glass is never proportional, the complete correction for achromatism is less simple than this would lead one to suppose, but for the purpose of illustration it is not at present necessary to further discuss this point. We saw that with a pair of lenses it was possible to correct for spherical aberration. The mathematical formula which must be satisfied in order to do so is by no means simple. I give it below without attempting to indicate the steps by which it is obtained. Anyone interested in the matter will find it fully discussed in Herschell's "Light."

FORMULA B.

$$0 = \left\{ \begin{array}{l} \dfrac{\phi'}{\mu'} \left\{ (2 - 2\mu'^2 + \mu'^3)\,\rho'^2 + (\mu' + 2\mu'^2 - 2\mu'^3)\,\rho'\,\rho'' + \mu'^3\,\rho''^2 \right\} \\ + \dfrac{\phi''}{\mu''} \left\{ (2 - 2\mu''^2 + \mu''^3)\,\rho'''^2 + (\mu'' + 2\mu''^2 - 2\mu''^3)\,\rho'''\,\rho'''' + \mu''^3\,\rho''''^2 \right\} \\ - \dfrac{\phi'\phi''}{\mu''} \left\{ (4 + 3\mu'' - 3\mu''^2)\,\rho''' + (\mu'' + 2\mu''^2)\,\rho'''' \right\} \\ + \dfrac{\phi'^2\phi''}{\mu''} \left\{ 2 + 3\mu'' \right\} \end{array} \right\}$$

where ϕ', ϕ'' = refracting powers of two lenses, μ', μ'', = refractive indices of the two glasses.
ρ' ρ'' = curvatures of first lens, ρ''' ρ'''' = curvatures of second lens.

Suppose, now, we wish to make up a system of two lenses out of two given glasses, and to correct it for spherical and chromatic aberration by means of these formulæ. We will assume the focus of one lens, and from formula A for achromatism we shall obtain the

focus of the second lens. We therefore know $\phi' \phi''$ and $\mu' \mu''$. What, then, are the unknown quantities in formula B? The four curvatures of the two lenses $\rho' \rho'' \rho''' \rho''''$.

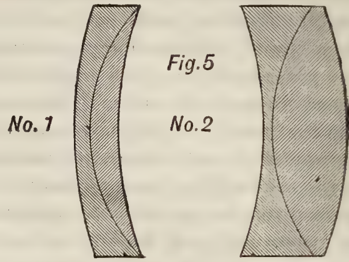
In the construction of photographic lenses we always endeavour to have as few reflecting surfaces as possible, in order that no large proportion of the light which enters a photographic lens may be reflected back again. Thus, in making an achromatic pair of lenses we endeavour to make one curve of each lens the same, and to cement the lenses together. That is to say, we make $\rho''=\rho'''$. This considerably simplifies the equation (B) we have only three unknown quantities, and, moreover, we have from the following two equations connecting them—

$$(\mu'-1)(\rho'-\rho'')=\phi'. \qquad (\mu''-1)(\rho'''-\rho'''')=\phi.$$

Thus we can reduce our formula to a form where only one unknown quantity exists. It is true it is an equation of considerable complexity, but when we have inserted the known quantities it is merely a matter of arithmetic to simplify it. Now arises a point of some interest. The solution of this equation will give us the shape of the lens that must be made in order to obtain a compound lens free from both spherical and chromatic aberration, and a lens of a shape that will not satisfy this equation will not be accurately corrected. It would therefore appear that for any two given kinds of glass the lens would have to be made of one particular shape and no other. But if we examine the expression in B more closely we shall find that when simplified out it becomes a quadratic equation, and that it has in general two roots, that is to say, with most kinds of glass two shapes of lenses can be made, each of which will give perfect correction for spherical and chromatic aberration.

There are glasses, which however we generally avoid, whose refraction indices and dispersions are such that the roots of the equation are imaginary, and we find that with these glasses it is impossible to obtain a system of this nature of any shape whatever that shall give a perfect correction for the aberrations. We shall find that in this case we must make lenses whose curves are not the same, which cannot therefore be cemented.

I have sketched the necessary shapes of the two forms of lens given by two kinds of glass which are in constant use, and it will be found that most of the glasses that have until recently been employed, will give for their corrected lenses shapes that are more or less similar to the two forms figured.

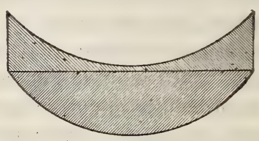


It is interesting to note that the form No 2 is that generally employed for telescopes, as the curves are less sensitive to slight alterations, while the shape No. 1 is that which is employed for a large number of photographic objectives, on account of properties which this form of lens possesses that I shall have again to allude to. In order to make this point more clear, I have sketched a series of lenses all made of the same two glasses, all corrected for achromatism, but in which only one is corrected, both for spherical as well as chromatic aberration.

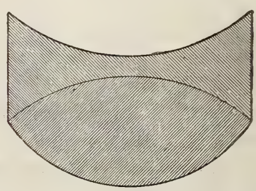
There are many ways of combining the lenses so as to correct one or other of the aberrations, but, as we have seen, in general only two for correcting the two together.

Fig. 6.

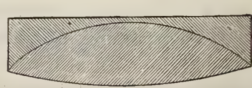
Series of Achromatic Combinations showing Different Degrees of Aberration.



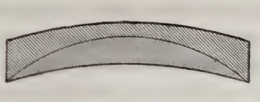
Spherical aberration of concave lens = $-\ \cdot198y^2$.
Do. do. convex lens = $+\ \cdot4404y^2$.
Do. do. combined pair = $+\ \cdot2424y^2$.



Spherical aberration of concave lens = $-\ 2\cdot769y^2$.
Do. do. convex lens = $+\ 3\cdot4056y^2$.
Do. do. combined pair = $+\ \cdot6366y^2$.



Spherical aberration of concave lens = $-\ \cdot8438y^2$.
Do. do. convex lens = $+\ \cdot5042y^2$.
Do. do. combined pair = $-\ \cdot3396y^2$.



Spherical aberration of		concave lens	$= -10{\cdot}52y^2$.
Do.	do.	convex lens	$= +10{\cdot}52y^2$.
Do.	do.	*combined pair*	$=$ O.

We have, so far, only considered that bundle of rays which passes through the centre of the lens, and forms the centre of the picture; and, as we have shown, it is necessary, in order that this portion of the picture should be sharp, that there should be no spherical or chromatic aberration. The question next arises as to what method is employed in order to obtain sharp pictures at the margin of the photographic plate; that is to say, by what means a bundle of rays, passing through the lens obliquely, may be brought to a single point.

Now, a good plan, undoubtedly, would be, to make a globe of glass, and use a spherical plate, except that the achromatism would be difficult to correct, and it would be difficult to use different apertures, or stops. For it is evident that a bundle of rays passing through a globe would be affected in an exactly similar manner, whether they passed straight through or at an angle. But the globe is impracticable; it has been tried, and has been discarded, for many reasons.

Another plan, which would work equally well, is, that the complete lens should be two portions of a hollow globe, of which the surfaces are concentric—thus. Here, also, you will observe the oblique rays would pass through a similar set of surfaces to the central rays, and, although a certain alteration would take place, we may say that, practically, the oblique rays would be refracted to a single point, provided central rays were refracted to one point.

Now, what are the ways in which opticians have hitherto corrected for the aberration of the oblique rays, which is called astigmatism? The globular lens was tried, and found unserviceable, and, though hitherto the concentric lens has been an impossibility, we have reason to believe that in the future this form of lens will be made. The method of correcting for this astigmatism has been by making the lens as nearly as possible of the concentric form. If it were quite concentric, the lens could not, with our usual glass, be made of the required refraction, so that we have been obliged to make lenses which are far from being concentric, but which, being made in the form of as deep meniscuses as we can make, somewhat approach the concentric form, and thus improve, but in no way annihilate, the astigmatism.

Let us suppose we are anxious to make a lens to cover a plate that subtends an angle of, say, 30° to 40°, and that shall have an aperture one-eighth of the focus. Suppose the focus of the lens be 10 inches, then the bundle of rays that enters the lens from any point of the object must be $\frac{10}{8}$ths, or $1\frac{1}{4}$ inches. The lens cannot be smaller, therefore, than $1\frac{1}{4}$ inches, and it is found, for other reasons, that it must be at least $1\frac{1}{2}$ inches. The deepest curve we can conveniently make of that diameter is, say, $\frac{9}{10}$ths of an inch, or thereabouts, and this limits the convexity of the meniscus that can be used. Well, we know that in order to correct astigmatism we require the lenses to be as deep as possible, and as nearly parallel as possible, so we decide to have our lenses of such curves that the deepest is about $\frac{9}{10}$th inch. We decide to have a pair of symmetrical lenses, in order to have no distortion, and that they shall be placed in a position to give as nearly as possible the form of a hollow sphere. Now comes the point what glass shall be used. We observed before that with every two kinds of glass the lenses could only be made of two shapes. Thus, we must look through our glasses to see which pair will best give us this deep meniscus form. We shall find that for a lens of the type I have mentioned, the glasses known as light and heavy flint combined together will give the nearest approximation to the shape required. That is to say, in order to be able to make a lens with these very deep curves we must use two glasses, whose refractive indices and dispersions are unusually close together, otherwise the adequate corrections cannot be obtained. For a lens with a larger aperture than one-eighth of its focus the lenses must be larger; it is then no longer possible to employ so deep a curve as $\frac{9}{10}$th inch, as it would be more than a hemisphere and could not be made, and the curves must of necessity be of a flatter form. We must again look through the kinds of glass at our disposal, and we shall find that glasses with a greater difference between their refractive indices and dispersion must be selected.

This will have, I hope, indicated very roughly and briefly some of the general defects of a simple lens, which we, as opticians, endeavour to correct. For portrait lenses we devote ourselves beyond everything

to the correction of the spherical and chromatic aberrations of the central rays, because large apertures are necessary in order to make the lenses rapid, and the larger the aperture the more the defects in the aberration show up. That is to say, in portrait lenses we devote ourselves to the central definition of the lens. In rapid and wide angle doublets, although the central aberrations must be carefully attended to, the corrections for astigmatism and distortion are the most important. Again, with single landscape lenses a certain amount of distortion is tolerated in order to obtain better marginal definition. In order to describe all the different details of construction, it would not require a single paper but a series, and I doubt if any but opticians would be interested. I have been unable to touch this evening on many points of special interest.

The flare-spot and its causes and modifications in various kinds of lenses would be a subject that, to be fully treated, would require considerable time. Wherever light meets a polished surface of glass a portion of the light is refracted and a portion is reflected, and thus with every lens a certain amount of light enters the camera which has not passed straight through the lens, but has been reflected backwards and forwards from the various surfaces of the combination before entering the camera. The amount of this light is exceedingly small, compared with the body of light which passes through the lens, and if it is diffused over the whole of the photographic plate, it has no appreciable effect. It, however, sometimes happens in a carelessly adjusted lens, more usually of the doublet form, that the greater portion of this light thrown into the camera by internal reflections is concentrated upon one part of the plate, and forms a patch of light called the flare-spot.

Another interesting point is the special chromatic correction which has to be made—owing to the irrationality of the spectrum—in order to make the focus coincident for the chemical and visual rays. In this connection, you will no doubt expect me to speak of the new optical glass which hae recently been made at Jena. I think it has sometimes been supposed that the advantage that would be gained by the use of this glass for photographic objectives would be mainly due to the destruction of the secondary spectrum. I anticipate no improvement worth mentioning from this cause. Those who are familiar with that beautiful optical correction of a telescope object-glass, and who have compared it with the correction of the best photographic objectives which are purposely imperfectly corrected in that direction, will realise that the correction of the secondary spectrum is of very little consequence in the construction of photographic lenses. There are now being turned out from the glass factory at Jena over ninety kinds of glass, and some of these possess very remarkable qualities, such, that I think it not impossible that we may be able to make in the future a doublet lens that is absolutely concentric, and in which the covering power is thereby largely increased. There are many serious difficulties in the way, and although the firm of which I am a member have been for many months working in this direction, the investigations are not yet sufficiently complete for me to be able to give you any definite information as to their results.

I will not to-night discuss the much debated point as to whether it is legitimate to leave a lens more or less imperfectly corrected for aberration in order to obtain the so-called "depth of focus." All such points as these may appear to be of secondary importance, but they must nevertheless be carefully considered in the construction of photographic lenses.

In concluding this paper, I hope I may be excused if I make one or two remarks on the methods of constructing optical instruments. When the principle of achromatism was discovered, the achromatic telescope was made by Dollond largely from practical experiments. The achromatic microscope was worked out by Lister and others by practical methods, and even at the present time many things are done in practice which are not even known of by theoretical men. I believe I am correct in saying that there is no book which gives a correct representation of a high power microscopic object-glass, and most of the figures which are to be seen in books are entirely misleading.

There can be no doubt that in certain branches of optics the practical man formerly led the way, and it was only afterwards that his methods were theoretically explained. This naturally produced among opticians a certain contempt for theoretical work, while the theoretical men were somewhat sceptical of the rule of thumb mode of inquiry often employed by the instrument maker. Thus it comes to pass that we find in England, except in rare instances, very little combination of practical and theoretical men in the pro-

duction of optical instruments. Practical men are realising that although the improvements that have in past years been made in optical instruments have been in a great measure due to the empirical method of inquiry, now that the science is more completely worked out, and the conditions have become less simple, the advances that will in future be made will undoubtedly be due more or less to theoretical research. Now we, opticians, are men of business, who have not only to make optical instruments, but also to make a living out of them, and have not so much time as we should like for theoretical work. What then is our annoyance when we find, on entering the study of the subject, that the books are now written, not that they may be of practical use, not that they may advance the science, but that the student may have simple formulæ and dodges to pass examinations. The pure mathematician is apt to be so impressed with the necessity of having a formula that is of a pretty and symmetrical form and easy to cram for examinations, that he sometimes arranges his signs and terms in a manner such, that in order to make practical applications of the same, the formula has to be entirely reconstructed. Is it not a disgrace to our literature that in optical text-books the thickness of a lens is generally neglected or merely mentioned as a corollary? It is only within the last year or so that any accessible English book has treated adequately of aberration since the time of Herschel. The investigation of oblique pencils is generally left almost untouched, and the question of signs is in a chaotic condition. If theoretical men will combine with us practical men by writing books by which we can educate ourselves in the direction we require, there are many improvements in optical instruments which, in the not distant future, we may hope to accomplish.

DISCUSSION.

The CHAIRMAN said it was now two years since he had the honour of addressing an audience in that room on the characteristics of the lenses then in existence, without any regard to theory. Mr. Beck had discoursed on the theory, so that in this case practice certainly went before theory. Mr. Beck said that a concentric lens had hitherto been an impossibility, as, if quite concentric, it would not have the required refraction. But some two or three years ago he examined one in which, so far as he could learn, the lenses were concentric. It was made of a glass of an exceedingly high index of refraction—some of the new Jena glass—and projected the oblique pencil practically perfectly on a flat plane. The aperture was somewhat small, however—about *f*-16. Some difficulty arose in obtaining the right kind of glass, but it was consoling to know that such a thing had been done. Mr. Beck had suggested a spherical lens as one which, if obtained, would give marginal definition on a curved plate; but many years ago Mr. Sutton made a lens composed of a shell of fairly dense flint-glass, filled with water, and an ingenious diaphragm placed in it. It was a panoramic lens, embracing a wide angle. The plate was curved cylindrically, and the spherical aberration was very well corrected —sufficiently well, at any rate, to enable one to enlarge a picture taken with it two or three diameters.

Mr. T. R. DALLMEYER said he did not quite follow Mr. Beck in what he said about theoretical men. They were in many ways indebted to Sir George Airy's treatise on spherical aberration, and he afterwards summed it up in a practical form for opticians who did not understand the subject. Only a day or two ago he was looking over a paper by the late Peter Barlow, who worked with Dollond, and he there said in a particular instance in which he described a negative achromatic eye-piece, that although he gave the formulæ, opticians as a rule had to sacrifice a very great deal of mathematical elegance to the utility of practical observation. When you had theoretically arrived at the main principles to work upon, a man used to observing the character given by the lenses—in such as the image, and so on—would know in what direction to work on that lens afterwards. It was impossible for anyone, however clever theoretically, to gain anything through a calculation of the excentrical pencil. The excuse made for the mathematical men not going into the subject was that it was too cumbersome; there was no prettiness in it. The results were laborious, and when obtained you gained very little information which you would not obtain better by a little practical effort after first arriving at the approximate result theoretically. With regard to Jena glass, he had one or two specimens which were very full of colour, and the surfaces were not to be relied upon, so that he had not done much with it. However, on high authority, such as Dr. Vögel, they were told that these lenses were very successful, and as he did not think English opticians ought to be behind, he was working on the same subject.

Mr. L. WARNERKE asked if it were possible to have lenses suitable for ortho-chromatic photography, viz., with a coloured part added, in order to avoid the use of screens, which generally very much affected the sharpness of the image.

The CHAIRMAN said he presumed the question would include colour either in the glass itself or in

the cementing balsam, to act the part of a screen in orthochromatic photography. Captain Abney had suggested the application of coloured collodion to one surface of the lens.

Mr. WARNERKE said he had come to the conclusion, from his own experiments, that the use of the screen, either in front, behind, or between the lenses, and no matter how carefully prepared, spoiled the image.

Mr. DALLMEYER said no doubt that would be the case. If you looked directly through the parallel surface of the glass there was no effect on the position of the image, but if you looked obliquely through a parallel ray it was certain to be displaced. Captain Abney's plan, therefore, would be preferable if the colouring matter were applied equally to the surface. It struck him the other day that perhaps the best possible form would be a coloured glass, if it could be obtained homogeneous, placed parallel to the surface of the outside lens, and then possibly the rays coming in any direction would not suffer, but he was only speaking off-hand.

The CHAIRMAN remarked that history repeated itself. This plan had been suggested before Mr. Dallmeyer was born, by Emil Busch, in a very old treatise on photography. But in this case, the blue glass shell was for the purpose of obtaining the actinic effect.

Mr. BECK thought it must be obvious to everyone that if the glass of the lens itself were coloured there would be much more colour in the thicker part than in the thin. If you had a parallel plate of glass, the same lens would always have to be used with it, as it would alter the corrections.

Dr. LINDSAY JOHNSON asked for a definition of two words which one often met with, which he had seen used with quite different meanings. Dr. Monckhoven stated that an aplanatic lens was one which could be used with the full opening, and that an antiplanatic one had to be stopped down in order to get definition at the sides. On the other hand, Dr. Eder gave an absolutely different definition, saying that an aplanatic lens was one in which the two systems—the front combination and the back—were almost similar; whereas in an antiplanatic lens they were totally different, as in a portrait lens. The first definition seemed to him totally absurd, as you had only to cut down your lens sufficiently, as in one of Ross's portable symmetrical ones, and you had at once an instrument which could be used with full opening; yet if it were not cut down to small circles, instead of what Dr. Monckhoven would call an aplanatic lens, it would be an antiplanatic. In no book could he find an authoritative definition of these terms.

Mr. LYONEL CLARK said he understood Mr. Beck to mean by astigmatism spherical aberration of the oblique pencil, and he should like to know what difference there was between that and coma. If it were the same, it would somewhat simplify a rather troublesome correction. He was much pleased with the attack on examination papers, and the absurd mathematical way in which the simplest problems were obscured. One reason, probably, was that examiners were nearly always chosen from those who wrote books, and, consequently, those who went up for examination had mainly to find out what marvellous terms his examiner had happened to use. With regard to coloured glasses, as Mr. Beck had pointed out it was practically impossible, and certainly not desirable, to tint the glasses themselves, on account of the different thicknesses of the refractive surfaces, but in a discussion on the same point some time ago, it was mentioned that it would be quite practicable to use a method which had been employed by the Chairman for a different purpose—to take two ordinary glasses, a positive and a negative, exactly correcting each other, and cement them together with coloured balsam.

The CHAIRMAN said there was another objection to the Jena glass besides the colour, which had been already mentioned, and one which seemed fatal. That was the liability of the surface, after it was polished, to disintegrate or rust, as he might term it. A distinguished London astronomer had a prism from abroad, made of a very suitable kind of glass, but after a short time it was found that the surface got rusty. He then had it cleaned and polished, and encased within parallel plates of harder glass, and it then became utilisable. If a glass of this sort were employed, as Mr. Dallmeyer employed the flint glass in his treble single combination, some benefit might arise; but he thought the Jena glass would bear a good deal of improvement before it could be used as ordinary glass. A method of applying colour in connection with spectacle glasses was patented some years ago, consisting of putting a film of coloured balsam or varnish between two surfaces of glass ground to the proper curvature. He did not know that they were much used, but he remembered seeing a lot of them sold off by auction not very long ago.

Mr. J. R. GOTZ said as far as his information went, an aplanatic lens was one free from spherical aberration, which brought the rays to a focus on a plane. The question arose next, with what portion of the aperture did it do that. Photographers required a large aperture, and the answer would be that when a lens was satisfactorily aplanatic, it was so with a large aperture. Almost every lens could be so with a small aperture, but a well-corrected first-class lens should be aplanatic with a large aperture, and that was the direction in which Continental opticians had been working. The antiplanat was simply a description of the form of the lens. The firm which brought out the so-called antiplanat

required to bring something new before the public, and, as far as he could understand, the term simply applied to the form in which it was ground. With regard to the Jena glass, he thought there was a good deal of piecemeal information about, which gave it a character which it only partially deserved. Some of it was exactly the same as glass produced before by eminent firms, and would show the sodium and other lines coincident with it to about the third or fourth decimal. Such glass of course, might replace that which had been used, hitherto, perfectly well, as it could not be any more susceptible to atmospheric influence. There were other kinds, which were exceedingly white. For instance, there were some light flints which would almost replace the heavy flints, and with great advantage. The Jena people offered to make glass for opticians, giving any refractive index they required, or any required dispersion, and if they could do this, it was hardly right to complain of what they did. The establishment of the manufactory had been preceded by a good deal of research, which was supported by the Prussian Government, who found Messrs. Schott the necessary funds to make every possible experiment, and at last the experiments were completed, and the factory was established, under the protection of the Prussian Government. He thought it was a great credit to them, and that when these glasses were better known their value would be more appreciated.

Mr. CHAPMAN JONES said he had seen several examples of the Jena glass, but only one was affected by the atmosphere to any appreciable extent, and they were all remarkably free from colour, much more so than most flint glasses. In a depth of four or five inches one might almost call it colourless. With regard to the use of coloured screens, he thought it possible, by putting the screens either in front or behind the lenses, to cure curvilinear dispersion in a single lens.

Mr. THOMAS S. TAYLOR, while thanking Mr. Beck for his interesting paper, thought there was one matter he had somewhat overlooked. He said that to cure astigmatism it was necessary to have lenses of deep curves, but he ventured to think that that was a misapprehension. What he meant by astigmatism in a lens was that the oblique pencils were practically what was known as the circle of least confusion. He should put the matter thus:—To obtain a flat field in a photographic lens, to make the rays at the edge of the plate to coincide in the same plane with those in the centre, deep curves were necessary. It was possible to obtain practically no astigmatism in a lens which gave a very concave field. If you got the centre in focus, with no astigmatism, and then pushed the glass a little further in and focussed the edge, you had very little astigmatism, if the lens had flat curves; but if it had deep curves, you had the maximum astigmatism. Therefore, he came to the conclusion that it was impossible to have a flat field together with freedom for astigmatism; the two were physically opposed, just as depth of focus and length of focus were. Mr. Beck had possibly overlooked one fact when he said that it might be possible with the Jena glass to make lenses perfectly concentric. If so, the convex surface of the lens would be flatter than the concave, and therefore it would minify, not refract, the concave surface being of shorter radius. This might be overcome, possibly by a difference in density, but as the lens was designed the denser one must be the convex one, with the concave surface inwards. He concluded, therefore, that astigmatism and flatness of field were physically opposed to each other. He fully agreed that Mr. Beck had done good service to optics, and to science generally, by his none too strong remarks with reference to examinations, and the impractical and useless application of formulæ in such examinations. With reference to the Jena glass, Mr. Gotz had referred to the possibility of any optician obtaining exactly what glass he required on giving the refractive index and the dispersion; but he (Mr. Taylor) thought that was the weak point in what the company proposed, because it seemed to him that so many different qualities would be produced, that it would be impossible to rely on getting two or more batches exactly the same. In England there were only a limited number of qualities obtainable, and therefore the quality was kept regular; and unless it were so, it would be necessary to re-calculate the curves for every batch of glass.

Mr. BECK, in reply, said the Chairman had referred to a globe-lens, which he thought was the same as he had mentioned as having been tried and discarded.

The CHAIRMAN said he referred, not to the so-called globe-lens, as formerly employed in America, but to the panoramic lens of Mr. Sutton, which was designed and manufactured in London; it had a perfectly spherical shell of glass, which was filled with water, and a diaphragm was fixed in it. The American globe-lens (which he sketched on the board) was of an entirely different construction.

Mr. BECK said he had meant to refer to Sutton's lens. The other was not really concentric, because it was made of ordinary glass. There was immense room for the mathematics in connection with optics to be written better. No one who had read such books as Parkinson's, and the ordinary mathematical books on optics, could help seeing that they were atrociously bad. Even Heath's book, which came out about a year and a-half ago, although it was a magnificent work in many ways, had this defect, that he defied anyone on reading it the first time to say how he reckoned his signs. With reference to the words aplanatic and antiplanatic, he only considered

them names for a particular form of lens, more of a commercial character than anything else. He took aplanatism to mean freedom from spherical aberration, which did not mean giving a flat field necessarily. A great deal had been said about the Jena glasses, and someone had mentioned forty-five different kinds. He had particulars of over ninety kinds, and had samples of, perhaps, forty, and some of it was equal in every respect to what they were in the habit of using, and, in fact, it was just the same; but some would not stand exposure to the air, and the great difficulty was that just those kinds which they wanted to use were those which would not stand exposure. Those which had the extraordinary qualities which would make it possible to do what Mr. Thomas Taylor seemed to think impossible, were those which would not stand exposure properly. Mr. Taylor doubted the possibility of making concentric lenses which should be refractive, and not give a minus effect, but he had thirty or forty lenses at his factory, which he should be glad to show him. He thought he was under some misapprehension about astigmatism. It meant the abberration of rays in passing obliquely through a lens, so that they did not come to the same point. When you had got the rays to meet, then came the question of flatness of field. If you corrected astigmatism you had a curved field. To perfectly correct flatness of field was largely a question of stopping down; but there seemed to him no impossibility in perfectly getting over the difficulty. It was said that it had been done in Germany, but whether that was so or not, time would show.

The CHAIRMAN then proposed a vote of thanks to Mr. Beck, which was carried unanimously.

Correspondence.

THE CHANNEL TUNNEL.

The question of the Channel Tunnel being a danger is entirely put in the shade by the fact of the splendid harbour that will shortly be opened at Calais. There will be room in it for one of the largest fleets to lie at the quays, and this within two hours steaming of our coasts. Now turning to the 20 mile or "one hour passage." Until quite lately the whole blame has been justly thrown on the French for having no port at which large steamers could enter. This complaint has been met by the French, and splendid passenger-boats can enter Calais at any time of the tide.

What have we got on our side of the Channel? A wretched harbour nearly dry at low water, and a stone pier which it is distressing to land at.

Being in Paris on business, I regret that I could not be present at the meeting on the 15th, as I wanted to prove that every arrangement was completed to provide quarters for the men who were to make the outer wall of the new harbour of Dover; plans were agreed on, but for some reason all was stopped, so that the passengers coming from Belgium and France by the new boats justly curse the authorities who are so shortsighted, and as to the French, who hearing that fine large English steamers enter their port of Calais, they are screwing up their courage to visit England, but when they arrive they have to be helped ashore, owing to the steamers rolling so much when fastened to a "stone pier" in an open sea-way unprotected in rough weather.

THOS. CHRISTY.

RAILWAY SLEEPERS—TIMBER OR METAL?

In number 1,884 of the *Journal* (Dec. 28th) is a note giving striking statistics as to the destruction of forests caused by the demand for timber railway sleepers. One statement is that the French railways alone cause the consumption of 1,000 fine trees per day. If this basis be taken for all railways, now and prospectively, under construction, the waste of timber and rapid denudation of forests from this cause is appalling, from the standpoint of broad public interests. Can the many men of light and leading amongst our members submit to leave this problem of engineering and forest conservancy to the blind operation of current demand and supply? It seems to me a subject which should be teken into serious practical consideration, with a view to ascertain if some suitable substitute for timber can be devised to meet the inexorable demand for railway sleepers. The iron "pot-sleepers," at one time used in Egypt and other countries where the soil is light and friable, seem to have have been discarded of late. On some of the Indian railways steel sleepers are being tried. At a recent meeting I put the question as to whether this material, considering its rigidity and other possible drawbacks, would be likely to answer the purpose. The chairman, with the caution due to long practical experience in railway construction, replied that this could only be determined by long-continued experiment on a large scale. The material must be durable beyond all comparison with timber, and if some fair degree of certainty can be obtained by special experimental testing, it seems to me that a carefully arranged plan with that object should be devised, so that the terribly rapid rate of timber consumption—with which no natural growth of forests can possibly keep pace—may be checked in time. Let us hope that some of our engineering members can give an authoritative opinion on this subject.

W. MARTIN WOOD.

TRADES GUILDS.

Mr. W. Cave Thomas writes in reference to the advocacy in Sir James Linton's paper of a revival of Trades Guilds:—I have at various times pleaded for the revival of guilds, as I considered that such a revival should have been one of the very first and foremost of the measures adopted for the advancement of the status of England's crafts. In 1873, I wrote, "All that is really required to set special, *i.e.*, technical education, in order, is a revival of the Trades Guilds, for this practical purpose." In 1875, "There can be no possible doubt that the City Guilds might greatly advance the interests of their special crafts, not by attempting to teach these to workmen, but by collecting all the records and information possible concerning their special crafts, accounts of what has been done, and is still doing in them, in foreign countries, by obtaining descriptions of new processes, &c.; by offering rewards for fine specimens of workmanship; and by constituting them tribunals for the settlement of trade disputes;" and again, "The proper function of a City Guild should be, as it was in the past, to mind its own business. To collect every information in reference to its craft, books, designs, engravings, &c., and to render these easily accessible to craftsmen. To pay a travelling agent, a craftsman, to prospect what is being done on the Continent in his line, and to report the same at head-quarters. The Guild should issue a journal for the purpose of keeping the craft at large *au courant* of what is being done abroad. Every guild should constitute itself into a tribunal to which trade disputes might be referred. When I say, that the proper functions of a Trades Guild is to my mind its own business, I do not mean it impertinently, but as concisely expressing a trade maxim, which every guild should adopt in its absolute literal sense." In 1887, I wrote, "The re-instatement of the guilds as trade intelligence departments; each guild should collect every kind of information appertaining to the craft it represents, and should be the centre of reference for that craft."

This is a matter in which the workmen themselves should take action. Guilds should be scattered up and down the country, and the workmen, knowing exactly what they want in the way of instruction, would obtain it. I would, however, advise the revival of the City Guilds as head centres, and on a footing consonant with the times.

APPLIED ART.

Sir George Birdwood writes:—"I find that the two statements made by me, in the course of my remarks on Sir James Linton's admirable address last Tuesday week, namely, that South Kensington possessed no Wedgwoods, and the Glasgow Museum no Tassies, are both entirely untrue. My only excuse is that, in making these misstatements, I was relying on a friend whom I supposed to be a complete master of the facts."

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday evenings at Eight o'clock:—

February 6.—"The Status of the County Council." By G. L. Gomme, F.S.A.

February 13.—"Salt: its Production and Consumption at Home and Abroad." By Peter Lund Simmonds, F.L.S.

February 20.—"The Forth Bridge." By Benjamin Baker, M.Inst.C.E.

February 27.—"The Irish Lace Industry." By Alan S. Cole. The Duke of Abercorn, C.B., will preside

March 6.—"Arc Lamps and their Mechanism." By Prof. Silvanus P. Thompson.

March 13.—"The Manufacture of Aluminium." By William Anderson, M.Inst.C.E.

Foreign and Colonial Section.

Tuesday evenings, at Eight o'clock:—

February 19.—"Slavery in its relation to Trade in Tropical Africa." By Commander V. Lovett Cameron, C.B., R.N.

March 12.—"Borneo." By Robert Pritchett.

Applied Art Section.

Tuesday evenings, at Eight o'clock:—

February 5.—"Manufacture of Sèvres Porcelain." By Edouard Garnier.

February 26.—"English Bookbinding in the Reign of Henry VIII." By W. H. J. Weale.

March 19.—"The Art of the Jeweller." By Carlo Giuliano.

April 9.—

May 14.—"Venetian Glass." By Dr. Salviati.

Indian Section.

Friday evenings, at Eight o'clock:—

February 15.—"The Ruby Mines of Burmah." By G. Shelton Streeter. Sir Charles E. Bernard, K.C.S.I., will preside.

March 8.—"The Present Condition and the Prospects of Indian Agriculture." By Prof. Robert Wallace.

March 29.—"The Progress of the Railways and Trade of India." By Sir Juland Danvers, K.C.S.I.

May 3.—"The Karun as a Trade Route." By Major-General Sir R. Murdoch Smith, K.C.M.G.

May 24.—"Indian Wheats." By John McDougall.

Cantor Lectures.

The following course of Cantor Lectures will be delivered on Monday evenings at Eight o'clock:—

W. J. LINTON, "Wood Engraving." Two Lectures.

LECTURE I.—FEBRUARY 11.—Wood-engraving in olden time, Babylonian and Egyptian—Its beginning in Europe—Helgen, or Saint-Pictures, and Playing-cards—Early Specimens—Saint Christopher and the Brussels' Virgin—Block-books—The Apocalypsis, Book of Canticles, Biblia Pauperum, Ars Moriendi, and Speculum Humanæ Salvationis—Albert Dürer, his work aud influence on engraving in wood—His Apocalypse, Greater and Lesser Passion, and Life of the Virgin — The Emperor's Arch of Triumph — Jerome Andreæ.

LECTURE II.—FEBRUARY 18.—The Arch of Triumph—Burgkmair's Procession—The Triumphal Car—Sir Theurdank and the White King—Holbein's Dance of Death—The Engravings by Lutzelburger —Their special value—The meaning of *fac-simile* —Stothard and Clennell—Knife-work and graver-work—What is white line—Bewick and his school—Later work—Thompson and Harvey—Decadence—Art and Mechanism — Photography—The American 'New Departure."

MEETINGS FOR THE ENSUING WEEK.

MONDAY, FEB. 4...Farmers' Club, Salisbury-square Hotel, Fleet-street, E.C., 4 p.m. Mr. C. S. Read, "Corn Returns."

Royal Institution, Albemarle-street, W., 5 p.m. General Monthly Meeting.

Engineers, Westminster Town Hall, S.W., 7½ p.m. Inaugural Address by the President, Mr. Jonathan R. Baillie.

Chemical Industry (London Section), Burlington-house, W., 8 p.m. 1. Dr. T. Z. Thorne, "Some Industrial Applications of Oxygen." 2. Dr. J. W. Zeather, "Note on Improved Laboratory Apparatus."

Medical, 11, Chandos-street, W., 8½ p.m.

Victoria Institute, 7, Adelphi-terrace, W.C., 8 p.m. Mr. J. J. Murphy, "The Factors of Evolution in Language."

London Institution, Finsbury-circus, E.C., 5 p.m. The Ven. Archdeacon Farrar, "Society in the Early Centuries, A.D."

TUESDAY, FEB. 5 ... SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Applied Art Section.) M. Edouard Garnier, "Manufacture of Sèvres Porcelain."

Royal Institution, Albemarle-street, W., 3 p.m. Prof. G. J. Romanes, "Before and After Darwin." (Lecture III.) "Evolution."

Central Chamber of Agriculture (at the HOUSE OF THE SOCIETY OF ARTS), 11 a.m.

Civil Engineers, 25, Great George-street, S.W., 8 p.m. 1. Adjourned discussion on papers by Mr. John Carruthers, "The Steep Incline on the Puerto Cabello Railway, Valencia;" Mr. Robert Wilson, "Cost of Working the Hartz Mountain Railway;" Mr. J. P. Maxwell, "Further Information on the Working of the Fell System on the Rimutaka Incline, N.Z." 2. Mr. L. F. Vernon-Harcourt, "Some Canal, River, and other Works in France, Belgium, and Germany."

Pathological, 53, Berners-street, Oxford-street, W., 8½ p.m.

Biblical Archæology, 9, Conduit-street, W., 8 p.m.

Zoological, 11, Hanover-square, W., 8½ p.m. 1. Mr. G. A. Boulenger, "The Species Batrachians of the genus *Rhacophorus* confounded under the name of *R. maculatus*." 2. Mr. P. Sclater, "Characters of some new Species of Birds of the Family Dendrocolapitadæ." 3. Rev. O. P. Cambridge, "Some new Species and a new Genus of Araneidea."

WEDNESDAY, FEB. 6...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. G. L. Gomme, "The Status of the County Council."

Geological, Burlington-house, W., 8 p.m. 1. Dr. Joseph Prestwich, "The occurrence of Palæolithic Flint Implements in the neighbourhood of Ightham, Kent; their Distribution and Probable Age." 2. Mr. S. S. Buckman, "The Cotteswold, Midford, and Yeovil Sands, and the division between Lias and Oolite."

Cymmrodorion, 27, Chancery-lane, W.C., 8 p.m. Mr. A. N. Palmer, "The Early History of Bangor Monarchorum, with an account of the district east of Offa's Dyke, reconquered by the Northern Welsh in the 11th Century."

Entomological, 11, Chandos-street, W., 7 p.m.

Archæological Association, 32, Sackville-street, W., 8 p.m.

Obstetrical, 53, Berners-street, W., 8 p.m. Annual Meeting.

THURSDAY, FEB. 7...Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

Linnean, Burlington-house, W., 8 p.m. 1. Prof. P. H. Duncan, "Revision of the Gehinoidea." 2. Mr. A. D. Michael, "New British Parasitic Acari."

Chemical, Burlington-house, W., 8 p.m. 1. Profs. Meldola and G. T. Morgan, "Researches on the Constitution of Azo and Diazo-derivatives." (Part V.) 2. Dr. A. E. Armstrong, "*Résumé* of researches on the laws of Substitution in the Naphthelene Series." 3. Mr. A. G. Perkin, "The Action of Nitric Acid on Anthracene." 4. Mr. N. Collie, "Note on Methyl-fluoride."

London Institution, Finsbury-circus, E.C., 5 p.m. Mr. Harry Quilter, "Men, Women—and Artists."

Royal Institution, Albemarle-street, W., 3 p.m. Prof. J. W. Judd, "The Metamorphoses of Minerals." (Lecture III.)

Archæological Institution, 16, Burlington-street, W. 4 p.m.

FRIDAY, FEB. 8 . United Service Institute, Whitehall-yard, S.W., 3 p.m. Major-Gen. C. H. Owen, "The Value of Artillery in the Field."

Royal Institution, Albemarle-street, W., 8 p.m, Weekly Meeting, 9 p m. Sir William Thomson, "Electrostatic Measurement."

Civil Engineers, 25, Great George-street, S.W. 7½ p.m. (Students' Meeting.) Mr. J. D. Twinberrow, "Flexible Wheel-bases of Railway Rolling-Stock.

Astronomical, Burlington-house, W., 3 p.m. Annual Meeting.

Quekett Microscopical Club, University College, W.C., 8 p.m.

Clinical, 53, Berners-street, W., 8½ p.m.

New Shakspere, University College, W.C., 8 p.m. Mr. W. Poel, "The Stage Arrangement of 'Romeo and Juliet.'"

SATURDAY, FEB. 9...Physical Science Schools, South Kensington, S.W., 3 p.m. 1. Annual General Meeting. 2. Prof. A. S. Herschel, "Physico-Geometrical Models."

Royal Institution, Albemarle-street, W., 3 p.m. Prof. Ernst Pauer, "The Character of the Great Composers, and the Characteristics of their Works." With Illustrations. (Lecture III.)

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FRIDAY, FEBRUARY 8, 1889.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

MOTORS FOR ELECTRIC LIGHTING.

The Council, on the award of the judges, Prof. A. B. W. Kennedy, F.R.S., Dr. John Hopkinson, F.R.S., and Mr. Beauchamp Tower, have awarded a Society of Arts Gold Medal to each of the following competitors:—

Class A.—Motors in which the Working Agent is also produced.

Steam.

Davey Paxman and Co., Standard Iron Works, Colchester. — Eight horse-power compound portable engine.

Class B.—Motors to which the Working Agent must be applied.

Gas.—Engines worked by Illuminating or other Gas.

1st. Motors under ten horse-power (actual).—British Gas Engine and Engineering Co., Albion Works, Mansfield-road, Gospel-oak, N.W. — Six horse-power nominal Atkinson's "Cycle" gas-engine.

2nd. Motors over ten horse-power (actual).—Crossley Brothers Limited, Openshaw, Manchester. — Nine horse-power nominal "Otto" gas-engine.

3rd. Dick, Kerr and Co., 101, Leadenhall-street, E.C.—Eight horse-power "Griffin" gas-engine.

The report of the judges will be published in the *Journal* as soon as the necessary illustrations have been prepared.

Proceedings of the Society.

NINTH ORDINARY MEETING.

Wednesday, February 6, 1889; Edward C. Robins, F.S.A., Member of the Council, in the chair.

The following candidates were proposed for election as members of the Society:—

Hall, Sir Basil F., Bart., Dunglass, Cockburnspath, N.B.
Hardinge, Viscount, South-park, Penshurst, Kent.
Lawson, Vincent Alexander, 9, Rowcroft, Stroud, Gloucestershire.
Newton, A. J., Sheriff of London and Middlesex, Northwood, Chislehurst.
Thomas, William Kingdom, 16, Berkeley-place, Clifton, Bristol.

The following candidates were balloted for and duly elected members of the Society:—

Canning, Francis Lennox, Box 153, Johannesburg, Transvaal, South Africa.
Elliot, Hon. George F. S., 2, Pont-street, S.W.
Fenning, Rev. William Dunkin, Haileybury College, Hertford.
Johnston, Henry Augustus, 6, Drapers'-gardens, E.C.
Lishman, George, Salway-house, Leyton.

The paper read was—

THE STATUS OF THE COUNTY COUNCIL.

By George Laurence Gomme, F.S.A.

Of the capacity of the English race for administration there can, I think, be no manner of doubt. Wheresoever they have planted themselves on the earth's surface, whether by conquest or by peaceful settlement, the efforts put forth to obtain their footing in the new land have been promptly followed by efforts for administering their new territory. Those of us who have been careful to watch the doings of the English race abroad, or those who have been eager to read of their doings in the great colonial settlements that are now growing up into nationalities, or in the great dominions of Canada or India, are never at a loss to recognise this fundamental characteristic of our race. It is recognisable at all times, and on all occasions when the circumstances of the case call it forth, and I venture to draw attention to it to-night, because I

think it was pre-eminently called forth when the history of county councils began its long course. I want, on this occasion, to appeal to that history for some important practical results; I want to set forth the facts which show that county councils are as vital a part of the English constitution as the national council, or Parliament, that they have never really ceased to exist, in some form or other, since the earliest times of English history, and that their position in the constitution is very high, second only indeed to the national council itself. And at this juncture in our history I hold it to be absolutely necessary that we should properly understand these points. The great body of Englishmen, alas, deem any appeal to history to be superfluous and unnecessary; possessing that innate power of administration to which I have already alluded, they despise the lessons of past experience as of no avail, and I feel that an apology is almost necessary at the outset of my paper for the historical retrospect that I shall be compelled to make. However, I think if I succeed in showing that the inheritance of a magnificent past points to the possibilities of a magnificent future, and enables us to better understand what we may really expect of County Councils, few will be inclined to condemn the appeal to history. And then, again, I have this to point out—that what our race is doing now when they take over Burmah or Zululand they did when they took over Britain, their doings then and now being but different phases of one great national characteristic.

The County Council is the assembly of the county or shire, and between the county and the nation there is no higher unit which has any definite meaning in constitutional history. In this one fact we have the key to the preservation of this local unit. From the earliest times the shires have been the centre of considerable local feeling. Thus there grew up different rhyming couplets, which satirically or seriously describe the men of the shires.

Essex full of good housewives;
Middlesex full of strifes;
Kentshire hot as fire;
Sussex full of dirt and mire;
Norfolk full of wiles;
Suffolk full of stiles.

We of this age have left off rhyming about our county neighbours, but still the element of county independence is kept up as vigorously as ever, as witness that our soldiers now earn their laurels on the sands of Egypt, or on the border hills of India, as men of the Berkshire Regiment, the Lancashire Regiment, and so on; that our old and glorious national pastimes of cricket and football find their natural divisions in the county boundaries; and that men are still proud, even in commercial London, of remembering that they are Dorsetshire, or Yorkshire, or Kentish men born and bred. In this long-continued county feeling there lurks a phase of the oldest historic life in this country. It has stood the test of centuries of antagonistic powers, but so deep down lie its roots that Parliament, in this age of philosophical and experimental legislation, has again laid hold of the county unit upon which to base its new departure in legislation for local government. When one contemplates how insensibly the efforts of modern legislation have thus drifted towards institutions which have survived from the earliest times by natural laws (as inherent to the life of institutions as to the life of the animal world), it is idle to neglect the lessons which the history of such institutions has to tell. We start off, then, with the following propositions—that the county unit has a vitality of its own, derived from far back in the past, and continuing in vigorous form to the present; that it is not a mere agglommeration of localities contiguous to each other, and divided off into separate areas; that this vitality expresses itself in different counties in different ways, and that, therefore, it is a powerful instrument in the hands of those who will gather up all its various attributes and forces for the purpose of bringing out all the best that is in it for the good of the nation at large; and, finally, that no other area could step in between the county and the nation—it is the highest possible development of local institutions.

Dealing, then, with this indestructible unit, the county, the first point to which I am desirous of asking your attention is its origin and early constitution as a centre of government. In continental countries it has no parallel, and alike in its origin and duration it is entirely English. In the first place we can account for its name—county, that being the Norman word for designating the Anglo-Saxon shire. If we begin with the oldest shires, we have Kent, Sussex, Essex, Middlesex, Hampshire, Devonshire, Berkshire, Wilts, Dorset, Somerset, and East Anglian Norfolk and Suffolk—twelve in all. These are the settlements of the conquering English race in their then new land of Britain, and they represent the kingdoms which were founded by the new comers. The tenacity with which these ancient kingdoms

have kept to their own boundary lines at once marks a great characteristic of shire history. The other shires show equally important race elements. At the time of the West Saxon supremacy, the policy of transforming the conquered kings into earls, and their kingdoms into shires, was well understood, and as step by step the rest of England was brought under one sovereignty by Edgar, so the shire system thus inaugurated was spread. The great Northumbrian kingdom was gradually separated into Northumberland, Westmoreland, and Yorkshire. Cumberland was the English share or shire of the great Strathclyde British territory. The Middle Angles formed Herefordshire, Shropshire, Derbyshire, Staffordshire, Notts, and Leicestershire; the Huiccas formed Worcestershire and the neighbouring counties; Cornwall was West Wales, one of the last retreats of the conquered Celts. Thus the main principle at work in the formation of the shires was that of tribal distinctions, and when scholars of this age began to collect the remnants of English dialects still traceable in local speech, they found that the readiest and simplest line of division between one dialect and another is still the boundary lines of the shires.

The men of these independent kingdoms, or tribes, were governed, as in all Teutonic lands, by a chief or king, and a council. When each kingdom became subjected to a central king of the English, the monarch left intact the old institutions, and allowed the newly-formed shires to carry on their internal affairs by themselves, just as in India, at this present day, we retain our overlordship there, and leave the princes of India and their kingdoms units of the Empire. Thus the old council of the kingdom of Kent, or Sussex, or Essex, became the shire-moot of those counties. Nothing like the shire-moot meets us in Teutonic institutions elsewhere than in England, and it is this shire-moot which is, I submit, the direct ancestor of the modern County Council.

In dealing with this question of ancestry, I shall have to point out where some of the links of the chain have become extremely thin, and where deviations from the normal line of development have been very considerable. But still, throughout the long period from the 8th to the 19th century, England has never been without a system of local government based upon the old shire units, and this system has been, in some shape or other, in continuous succession from the shire-moot of Anglo-Saxon times. At the two ends of this long period the shire government is practically the same in constitution. During a long intervening period it developed into two branches, one of which assisted in building up the representative House of Commons, the other kept alive the shire organisation as an element in English institutions. In the course of this period of transition in the shire history of England, we come upon facts which will materially help us to understand the present position of County Councils, and it is to this transition period that I shall now ask attention.

It will be well to commence with an example of the ancient shire-moot, and for this I go to the county of Kent. The earliest collection of English dooms or laws extant, namely, that dated 675, belongs to the old kingdom of Kent, and the eighth paragraph reads as follows:—"If any man make plaint against another at the methel or the thing, let the defendant always give security to the other, and do him such right as the Kentish judges prescribe to him." After Kent had become a shire instead of a kingdom, the same local jurisdiction existed—local matters were still administered by Kentish judges. For proof of this I turn to the reign of William the Norman, six years after the battle of Hastings. I shall use a translation of the earliest recorded account of the transaction I am about to record, because there can be no improvement upon the simple terseness of the chronicle language:—

"In the time of the great King William, who conquered the English kingdom and subjected it to his rule, it happened that Odo, Bishop of Bayeux and the king's brother, came into England much earlier than Archbishop Lanfranc, and resided in the county of Kent, where he possessed great influence and exercised no little power. And because in those days there was no one in that county who could resist a man of such strength, by reason of the great power which he had, he seized many lands belonging to the archbishopric of Canterbury, and some customs, and by usurpation added them to his rule. But it happened not long after this, that the aforesaid Lanfranc, Abbot of Caen, also came into England, by the king's command, and, by the grace of God, was raised to the archbishopric of Canterbury, and made primate of all the realm of England. When he had resided there for some little time, and found that many lands anciently belonging to his see were not in his possession, and discovered that, by the negligence of his predecessors, these had been seized and distributed, after diligent inquiry, being well assured of the truth, as speedily as possible, and without delay, he made suit to the king on that account. Therefore the king commanded all the county [*comitatum*

totum] to sit without delay, and all the men of the county — Frenchmen, and especially Englishmen learned in the old laws and customs—to assemble. When these were assembled on Pennenden Heath [*apud Pinendenam*], all together deliberated. And when many suits were brought there for the recovery of lands, and disputes about the legal customs were raised between the archbishop and the aforesaid Bishop of Bayeux, and also about the royal customs and those of the archbishop, because these could not be ended on the first day, the whole county [*totus comitatus*] was detained there for three days. In those three days Archbishop Lanfranc recovered many lands which were held by the bishop's men—namely, Herbert, son of Ivo, Turold of Rochester, Ralph de Courbe-Espine, and many others, with all the customs and everything which pertains to those lands—from the Bishop of Bayeux, and from his men above mentioned, and from others, namely, Detlinges, Estokes, Prestetuna, Damtuna, and many other small lands. And from Hugh of Montfort he recovered Rucking and Brook: and from Ralph de Courbe-Espine, pasturage of the value of sixty shillings in Grean [Island]. And all those lands and others he recovered so free and unquestioned, that, on that day on which the suit was ended, not a man remained in the whole realm of England who could make any complaint thereof, or bring any claim, however small, to those lands. And in the same suit, he recovered not only those lands aforesaid and others, but he also revived all the liberties of his church and all his customs, and established his right in them when revived—soca, saca, toll, team, flymena, fyrmthe, grithbrece, foresteal, haimfare, infangentheof—with all their customs, equal to those or smaller, on land and on water, in wood, on road, and in meadow, and in all other things within the city and without, within the burg and without, and in all other places. And it was proved by all those upright and wise men who were there present, and also agreed and judged by the whole county [*toto comitatu*], that, as the king himself holds his lands free and quiet in his domain, the Archbishop of Canterbury holds his lands in all things free and quiet in his domain. At this suit were present Geoffrey, Bishop of Coutances, who represented the king, and held that court; Archbishop Lanfranc, who, as has been said, pleaded and recovered all; also the Earl of Kent, namely, the aforesaid Odo, Bishop of Bayeux; Ernest, Bishop of Rochester; Agelric, Bishop of Chichester, a very old man, and most learned in the laws of the land, who was brought there in a wagon, by the king's command, to discuss and explain the ancient legal customs; Richard of Tunbridge; Hugh of Montfort; William of Arques; Haimo, the sheriff; and many other barons of the king and of the archbishop; and many men of those bishops; and other men of other counties; also men, both French and English, of much and great authority with all that county. In the presence of all these, it was shown, by many most evident proofs, that the King of England has no customs in all the lands of the church of Canterbury, except three only; and the three which he has are these:—First, if any man of the archbishop digs into the king's highway, which runs from city to city; second, if any one cuts down a tree near the king's highway, and lets it fall across the road. Concerning these two customs, those who are taken in the act while so doing, whether pledge may have been received from them or not, yet, at the prosecution of the king's officer and with pledge, shall pay what ought justly to be paid. The third custom is of this kind. If any one on the king's highway sheds blood, or commits homicide, or does any other unlawful thing, if he is seized in the act and detained, he shall pay the fine to the king; but if he be not seized there, and shall once more depart thence without giving pledge, the king can justly exact nothing from him. In like way, it was shown in the same suit that the Archbishop of Canterbury ought to have many customs on all the lands of the king and the earl; for, from that day on which Alleluia is ended to the octave of Easter, if any one sheds blood, he shall pay fine to the archbishop. And at any time, as well in Lent as at any other time, whoever commits that offence which is called cildwite, the archbishop shall have either the whole or the half of the fine—in Lent the whole, and at any other time either the whole or half of the fine. He has also, in all the same lands, whatever seems to pertain to the care and safety of souls."

Now if we analyse this record we have the following facts about the shire-moot of Kent in 1072:—

(1.) The dispute was between two Kentish men—Odo, Earl of Kent in this case more than Bishop of Bayeux, and Lanfranc, Archbishop of Canterbury.

(2.) The subject-matter of the dispute was the possession of landed property.

(3.) The attendance of all the men of the county, especially those learned in the old laws and customs.

(4.) The place of meeting on Pennenden Heath, in the open air.

From these facts it is clear that Kentish questions, in 1072, were decided by Kentish men; that the domain of national law did not then include the customary land laws; that local customs were interpreted by the inhabitants of the district, according to traditional usage; and that the meeting place was held in the old tribal fashion, and, as the evidence of Domesday shows, on the spot which was sacred to the gathering of the shire-moot of Kent.

Now the people who would be best acquainted

with local usage would be the inhabitants of the townships or manors in dispute between these two great magnates of the land, for when Domesday was compiled, the writs of inquiry were addressed to the constables of the hundreds and town reeves, as the best exponents of the existing facts; and as township and manor between them had jurisdiction over title to land, it follows that the shire-moot of Kent was, on this occasion, the court of appeal from the lesser courts, who could not settle so important a matter by themselves.

That the shire-moot of the Anglo-Saxon system was the supreme court of appeal on all questions of local government occurring within its area, may be shown by a reference to the two subordinate jurisdictions which appear after the 9th century, the hundred-moot and the township-moot. These had charge of almost all matters, legislative and judicial, which affected the lives of the people at that age. Among the duties which may still be discovered from the remnants of the evidence which exist may be mentioned:—

Township-moot:—

1. The making of assessments for judicial fines.
2. Institution of local inquiries fnr the central government.
3. The appointment of officers.
4. Abatement of nuisances.
5. Admittance of new land holders into the township.

Hundred-moot:—

6. Repairing of bridges and roads.
7. Judging of criminal and civil matters.
8. Witnessing transfer of lands.
9. Management of the system of frank-pledge, which supplied the place of the modern police force.
10. Distribution of the local burdens among the constituent townships.

We find repeated in these early courts of the English the fundamental principle of the entire Teutonic race, namely, that the administration of law and the administration of state matters were placed in the hands of popular assemblies, no distinction being then made between executive and administrative functions.

The history of these two courts, the township-moot and the hundred-moot, is a long and interesting one, bristling with facts which lead to the very heart of early English juridical history. But for our present purpose it is only necessary to state one or two stages in the history of the township and hundred, so far as they affect the shire.

Very early in its history the hundred-moot gave way, and its duties were transferred to the shire-moot. The township began to be broken up by the encroachment of manorial jurisdiction, a process which enables us to discover one of the most instructive chapters of the early history of English institutions, but of which all that may be said here is that parish and manor divided between them the duties of the older township. Thus the administering bodies at the dawn of political history had become the parish, the manor, and the shire, who divided between them nearly all the duties which the State took cognisance of in its relationship to the inhabitants of the kingdom. In this system the shire was the highest authority, and acted as the final court of appeal from the lesser courts, the king sitting in the shire court instead of having the matters in dispute transferred to his own court. This is a very lofty position for local government, but it is distinctly necessary to bear it in mind when we come to reconsider some of the stages in its history, so as to render the attitude of modern thought more in accord with the spirit of English institutions.

It is important for one moment to dwell upon the significance of the land laws being administered in the shire and manor courts. The land of the country was held upon a traditional tenure, which Mr. Seebohm has made familiar to many of us in his valuable history of the village community in England. Villagers and lord held their estates by virtue of a custom which bound them inalienably together, and no one, not even the central authority, could step inside this community and profess to know, let alone decide, what were the links which bound them together. It would have been no use for the men of one village to be called upon to decide questions in dispute between men of another village, because each village, while of course possessing much in common derived from their common ancestral home far back in Teutonic history, possessed customs of its own and powers of its own to deal with those who set themselves against these customs. It would have been still less use for men of Sussex to intervene in matters which only interested and could only interest the men of Kent, and thus it is that this famous example of the old shire-moot of Kent gathering together to do right between two men of Kent, stands out so pro-

minently in shire history as a typical example of the Anglo-Saxon system.

It will not have been lost sight of that the extreme local characteristics of Anglo-Saxon institutions led to the downfall of the Anglo-Saxon kingdom, and no truer note has been struck by the historical novelist than when Charles Kingsley put into the mouth of Hereward the indignant denial that the defeat of Harold meant the defeat of the English—it was simply the defeat of the local army. It was William's genius that converted the defeat of a local army into the conquest of a nation. William was a statesman as well as a soldier, and he set about building up the kingdom of England by withdrawing from local jurisdiction the basis of the future English constitution. Bit by bit the king's councils encroached upon the shire councils, king's law upon local law, king's peace upon the peace of tithing and hundred. If we take, for example, the history of the law of distress, we find that it was derived from one of the oldest tribal usages, represented in local law by the village pound; "an institution," says Sir Henry Maine, "far older than the Court of King's Bench, and probably older than the kingdom." Under the Norman kings everything customary was transposed into a legal rule. Prescriptive rights were turned into chartered rights, and nothing is more instructive than the many signs which illustrate how written legal formulæ and documents took the place of the old unwritten customary law.

If, under the influence of a growing advancement of legal science, and the establishment of a professional class of lawyers, customary law was surrendering some of its most famous *dicta*, it is not surprising that customary institutions should have to surrender something to the central Government. Indeed, in no other way could our constitution have been built up but by this means. As arable land became a factor in commercial life, as pasturage grew from a village institution to an important place in economic affairs, land questions grew outside the sphere of local customary law, and had to be decided by the king's lawyers. Other questions soon arose in the same manner until it became impossible to trust to "men learned in the old laws and customs." Thus the shire councils were gradually thrown back, and the king's councils were gradually brought forward. The process was indeed gradual. There is no enactment, no arbitrary ruling of a monarch, no legislative act of a parliament, to mark the abolition of the shire-moot. As a matter of fact it never has been abolished, and this important feature in its history may well be dwelt upon at a time when it once more comes into prominence.

The details of its later history cannot be given on an occasion like the present, but one or two of the principal stages must be noted in order to show clearly that county government ts continuous from the earliest times.

The institution of circuits for fiscal purposes by Henry I., the extension of judicial duties to these circuits by Henry II., mark the first distinct decline in the influence of the shire council. Then we come to the office of coroner, which was instituted in 1194. He was to be elected by the landholders of the county, not by the shire court, a fact which, far from pointing to popular rights, as is generally supposed, seems to me to be the introduction of a new power side by side with the shire council which, like all early assemblies, had, hitherto, had the control and election of its own officers. The responsibility for peace had rested with the old shire-moot, but in the 1st of Edward III. an enactment was made that good and lawful men should be commissioned to keep the peace in each county. This was the last step in the degradation of the old shire-moot. Gradually one new duty after another was imposed upon the justices of the peace, as they were soon called, until, in the end, they have been looked upon as the sole county authority. At one critical stage it seemed as if they might have become the direct and only taxing authority, but, fortunately, this was averted. They were intrusted with the direct taxation of county inhabitants, instead of assessing the parishes, in 1530 and in 1531; the first for the repair of bridges, the second for the erection of jails. But this was the last experiment in this innovating system—a system which would have destroyed local government in England. In 1601, the first Poor-law Act was passed, and the justices were chosen as the administrators, having the power of appointing the overseers in each parish, of levying contributory rates from the parishes, and of erecting houses of correction for undeserving beggars.

Up to this date we can trace the shire authority under an altered organisation, but still continuous in its functions from the earliest times. It has always had and still has both judicial and administrative functions.

We can also trace up to this date, and beyond it to some considerable time, the contribution of the old shire organisation

to the building up of the national council. Thus we have seen how the men learned in the old local laws and customs were superseded, as new laws and customs began to be dominant in national thought, by the growing powers of the king's courts of law. These men were not, however, entirely struck out of the forces which have been at work during the development of political institutions, for they were deputed to represent the shires in the Commons House of Parliament, and it is a thought worth bearing in mind that local government in the shires gave way just at the time when national government by representation was commencing its long course of development.

The knights of the shire were in their origin the men of the shire learned in the old laws and customs, just as they were at the shire council in 1072, because we have it in distinct evidence that long before the method of trial by jury was applied to civil suits and criminal proceedings, it had been the practice to ascertain local customs, grievances, and fiscal liabilities by local inquests. Without such previous investigations, says Mr. Brodrick, it would have been unsafe and sometimes impossible to enforce general laws emanating from a central executive, and even Parliamentary representation itself was originally little more than an expedient for obtaining the consent of local authorities to grants under, or enactments passed by, the national council, and gathering from the representatives of the local authorities the local usages which would enable the central authority to put into operation its measures. This is specially illustrated by the fact that the laws passed by the king and Parliament were considered and accepted by the shires before they were fully promulgated, a state of things which survived into quite recent times under the form of the county authorities being made the means for making known to the people the enactments passed by Parliament, and which has only passed away with the advent of the newspaper press.

If we turn to the history of local taxation, this position of the shire is very clearly seen. As Mr. Thorold Rogers very acutely remarks, "the convention of tax-payers" must have been held before the great charters of John and Henry, and the only machinery then available was the shire organisation. Stripped of much of its local administrative powers, it was still powerful as a taxing unit, and even now the county rate basis governs the assessment for Imperial and local rates and taxes. I am sure a few notes on the assessments which show from time to time the relative position of the counties will not be uninteresting at this point. In 1341, the assessments show that Middlesex (with London) stands first, then comes Norfolk, and then Oxford, while Lancashire is the poorest county. In 1375, Middlesex is again first, Oxford second. In 1636, Norfolk was third, Oxford seventeenth, Cambridge twenty-third. In 1641, Surrey is second, Suffolk third, Kent fourth, Norfolk sixth, Lancashire, Cumberland, Westmorland, Durham being among the last.

Before passing from these knights of the shire, learned in the old laws and customs, an extremely interesting point meets us at this stage, and takes us back to the famous shire council of Pennenden Heath. The spot where the sheriff took the poll for the knights of the shire—where, that is, the shire assembled in full force, not to legislate itself but to depute some of its members to legislate for it—is the same spot where of old the shire met when legislation was still in its own hands, that is, at all events, as late as 1072. This spot is historic, and it emphasises the connection between ancient and modern shire councils. The shire hall is situated on the north side of Pennenden Heath. Near it, at the meeting of the roads from Maidstone, is a lofty mound which is, or was, known as the "moot hill," that is, the mound of meeting; and on the opposite side was the gallows for the public execution of criminals, moot hill and gallows hill always going together in the primitive life from which both are derived. Surely it is something more than mere accident which, in Kent, and in many other shires besides, identifies a particular spot as sacred to the meeting place of the shire authorities; it is an expression of the genius of our race for a continuity of institutions.

We have now traced the old organization of the shire along the two lines of development, which the progress of the nation has forced it to take. We have also pointed out how one of these lines ended with the complete establishment of representative government; and we have traced the connection of the justices of the peace with the old shire councils up to the date of the first Poor-law enactments. This date marks the final break up of the old land laws by which, as we have seen, village communities lived self-contained and self-supporting; and here we come to the first great departure from the principles of shire government which, though in the

hands of commissioners, had still been left the head of local institutions. Poor-law administration was found too big a subject for the county commission of the peace to handle, and instead of reverting at this time to the old shire organisation, the local institutions of the country were set aside, and indiscriminate bungling began. As an historical student, I cannot altogether regret the terrible confusion which local government has got into because of its departure from historical lines, though I cannot but deplore the years of wasted energies and force which have been spent in finding our way back to the path from which during the last 150 years we have constantly strayed.

The parish, or union of parishes, was made the unit of local government for Poor-law purposes by an Act of 1723, enlarged powers being confirmed by the well-known Gilbert Act of 1782, and afterwards by a long series of Acts, beginning with that of 1834, from which is derived our present Poor-law system. This commences the first of many curious anomalies in local government, the result of which is that unions are unequal in size, and irregular in form, often cutting the boundaries of county and municipality, or local board district, always unequal in rating, oppressing the poor districts with enormous burdens, and leaving the rich districts with scarcely any burden; and yet, from the historical evidence, it seems impossible to suggest that any other but the county authority is the rightful administrator of Poor-law. As new developments in national life have taken place, all the old principles of local self-government have been persistently ignored until, in the end, we are met with such glaring inconsistencies as that one body of ratepayers is often governed locally by a Manor Court, a Vestry, a School Board, a Burial Board, a Highway Board, Sewerage Commission, the guardians of a Poor-law Union, and the Commission of County Justices.

I think we may detect from these facts where the old county system of government broke away from its traditional and historical position, namely, at the point where new local powers were found to be growing up, and could not be entrusted to an irresponsible body of commissioners. I say this in no invidious sense, but in an historical sense; for ever since Englishmen have governed themselves, they have in the main adhered strictly to the rule that representation goes strictly with taxation. On the other hand, attempts have been made to lay upon the county commissioners of peace duties which no popular body could have been asked to undertake. One instance of this is the regulation of labourers' wages under a long series of enactments from 23 Edward I. to the 1st of James I.; and although I think Mr. Thorold Rogers overstates the evil of their influence, there is no doubt of their injustice. Another instance is the attempt of James II. to destroy English liberties, when his first care was to obtain a pliable body of county commissioners, though, happily, neither lords lieutenant nor justices of the peace could be found base enough to betray their old county liberties. These features of county government are not many, but still, pure as it has been, it was instinctively recognised that it must not be entrusted with large powers of taxation; and so, in order to initiate the constantly increasing needs of local taxation, new body after new body has been created until we know nothing, instead of everything, about our local institutions. In the busy days of the present epoch simplicity in local administration is a *sine quâ non*, if efficiency is to be obtained; but to unravel the many ramifications of our local system bewilders the brain of a student, and utterly confounds the mind of the average elector who seeks to take his part in the duties of citizenship.

At this point of departure county government, as such, sinks into the background, and government by extremely small units, often not based on locality at all, comes to the front. But these small unhistorical units have never been seriously taken hold of by the nation. One half of the complaints of apathy in local government matters rests upon the fact that nowhere does the citizen come upon any account of these new units of local government outside of purely official publications, and I would venture to say that no one not immediately interested would, as a matter of choice, sit down to read the reports of the Local Government Board. No work on constitutional history, no work on the history of the English race, no class of literature, either of amusement or of study, even so much as mentions any one of them; whereas, parish officers and county administration are brought before the popular mind in hundreds of ways—in the plays of Shakespeare and in the works of the Bishop of Oxford. I may be pardoned a small allusion to family pride when I can definitely point to my ancestor, James Gomme, as bailiff of High Wycombe in the reign of

Edward IV. Many of us might now be interested to hold the same offices that were held by John Shakespeare, the father of our national poet. I believe in the continuity of national sentiment, and therefore it seems to me significant that we now once more go back to the system of county government.

If we turn our inquiry to ascertain the causes of the various changes in county government, we see it plainly written in the gradual change from an agricultural nation to a commercial nation. This change is typified by the burgh organisation, which comes right athwart the county organisation. More concentrated than the shire, richer, and with more defined requirements, the burgh communities soon became independent of shire authority. In our own days these burgh communities have again overlapped their original status, until we find in the great examples of London, Birmingham, Manchester, Liverpool, and others, that they are considerably more than boroughs or cities. Accordingly they have been promoted into counties, the only unit of administration which has no superior. This portion of the Local Government Act of 1888 is, I venture to think, one of the most distinctive signs of progress. Just as the Wessex king of old extended the shire organisation, founded upon the home government of old kingdoms, to parts of Britain which were not founded upon old kingdoms, so we of this age extend the county organisation of the old shires to districts which are of even more importance than the shires. It is extremely important to note this, because it shows how thoroughly suitable the shire or county system is to meet the often vexed question of what is to be the primary unit of local government. I shall have to say something more upon this presently, but in the meantime it may be pointed out that Mr. Goschen, in 1870, suggested the old parish as the primary unit, and others, with considerable cogency, have argued that the union of parishes under the Poor-law system should be the primary unit. But the facts of local government are against either of these suggestions. The example of London is only an example in concentrated force of what the parish or union system ultimately leads us to, and the only appeal from that system is to the county system, which means a county council as the one independent and initiative local authority, with all other local bodies subordinated to it, and administering delegated duties. This would facilitate the admirable suggestion by Mr. Broderick, that upon a local authority mismanaging its affairs the county authority should suspend its constitution for a time, and take it into its own hands, just as a corrupt borough is now deprived of the franchise.

If we now attempt to summarise some of the points which, in the short time at my disposal, I have been able to bring before your notice, we see that such a record as this speaks to us of a local institution of great dignity and of great importance, tells us of an original initial authority, not of a delegated authority, and suggests a long series of lapsed powers which may yet be recovered. Of course the county authority can never again become independent, but must receive its powers at the hands of Parliament. But what these powers are cannot be decided simply by a rigid adherence to the duties which have been imposed by the Legislature upon justices of the peace; for if we turn to the Act of 1888, there is one clause of enormous significance which has been strangely overlooked, but which I think contains more in it than all the other clauses put together. Clause 79 says:—"All duties and liabilities of the inhabitants of a county shall become and be duties and liabilities of the council of such county." Is it to be presumed that "all the duties and liabilities of a county" can be mentioned in detail in an Act of Parliament? Have mining Durham, agricultural Wiltshire, manufacturing Lancashire, fruit-growing Kent, no special duties and liabilities of their own, arising at any moment and in different ways? And can the multifarious duties of justices of the peace be set forth in the sections of an Act which only deals with their legislative powers? The justices of the peace, being the legislative successors of the four men and a reeve from each parish, inherit prescriptive rights from the old shire council which cannot be tabulated without a minute examination of the records of every county; and I would venture to suggest that County Councillors should get into the habit of looking into these old records and of publishing them to the world. Only a few weeks since anyone might have read in the papers the following passage:—

At Worcestershire Quarter Sessions, Mr. Willis Bund, Deputy Chairman, called attention to the recent report of the Labour Correspondent of the Board of Trade as to the condition of the nail makers and small chain makers of East Worcestershire. He moved that the Court should endeavour to obtain an extension to those trades of the Lords'

inquiry on the sweating system. He referred to the destitution which arose through the unfortunate operatives being subject to the oppression of "foggers," or middlemen, and said they were hardly able to earn enough to keep body and soul together, even by working from seven in the morning until nine at night.

This deals with the industry of the shire, and there are many other questions affecting industries which might adequately be dealt with more directly by the elected council of the shire.

Nothing is said in the Act about such functions as these, except the general clause to which I have drawn special attention. For one moment I will detain you by referring to some of the few printed accounts of county records, from which there is much to explain what the older powers of the county authorities are. The county of Cumberland registered the awards for enclosing commons under the county authorities, kept bridges in repair, and made orders for diversion of roads. The county authorities of Derby enrolled awards in respect of dividing and enclosing open fields, commons, and waste grounds, regulated the formation of new turnpike roads, navigable canals, and enrolled deeds of Papists' estates. The county of Durham enrolled the deeds of Papists' estates, copyhold enfranchisement deeds, the awards on the division of commons and waste lands, repaired roads and bridges, and regulated the diverting and stopping up of highways. The county of Lancaster enrolled all deeds and wills, and possesses the documents from 1595 to 1719, also Roman Catholic estates, the awards for the division and enclosure of commons. The authorities of Middlesex and of York register all memorials of deeds, conveyances, wills, and other encumbrances affecting lands in their respective counties. The county authorities of Devon in 1599 considered a petition from three parishes against having to contribute to the relief of the poor of Holsworthy, on the ground that the parish was well able to take care of its own poor, but the court ordered nine parishes, including the three appellants, to contribute; they also relieved such inhabitants as had their houses destroyed by fire (a State anticipation of modern fire insurance), two cases being Tiverton in 1596 and Cullompton in 1602.

I might go on quoting other examples, but perhaps these will suffice for my purpose. They are some of the duties which have been dealt with, as occasion necessitated, by the old county authorities; though many of them have, of course, become obsolete from the very nature of things, their originating power is included, though not enumerated, in the clause of the Act of 1888, which I have already read, and it must, of necessity, be handed over to the newly constituted county authority, successor to all that is best in the long history of county administration. These old and obsolete powers help us to understand that the status of the County Council is not to be determined by the exact terminology of a modern Act of Parliament, but by the long history which lies at the back of county government, and we must remember that the era of enclosures of common land, and the enfranchisement of copyholds, has not yet finally closed, and is capable of being reintroduced into local administration under a more modern but not less important aspect. Long ago, a distinguished jurist pointed out that it is one of the facts with which the Western World will some day assuredly have to reckon, that the political ideas of so large a portion of the human race, and its ideas of property also, are inextricably bound up with the notions of collective ownership of land. In England, the peasant world has lived upon its traditions and its memories, not upon the economic theories of an educated class, and they remember that their forefathers had rights of attendance at manor courts. The manor court has been inevitably passed by in the development of local institutions, and the county authority has taken over some of its powers. The peasant may yet be taught to look to the County Council for the modern equivalent of his older rights.

If we want an argument from modern times to back up the argument from history that the status of the County Council is so high as to draw to it very extensive powers, we may take the examples of the great commercial centres like London, Liverpool, Manchester, and so on. At first the London County Council will, perhaps, be the most powerful body in the kingdom, even though it does not, like other County Councils, have control of the police. All the powers and duties conferred by Parliament upon the Metropolitan Board are transferred to the London County Council, in addition to new powers imposed by the Act, and those transferred from the quarter sessions and the Metropolitan Asylums Board. But this arises from the fact that many powers vested in rural districts in smaller units have, in London, been vested in a large central unit. Before

this large central unit existed, that is before 1855, the modern county of London was in a deplorable condition. There were 250 different local Acts in force, administered by 300 different bodies, which consisted of no less than 10,448 persons. The creation of a central body in 1855, broke all these petty efforts at local government, in other words the central authority necessarily drew to it powers which, had there been no such authority, would have remained distributed among innumerable small bodies, many of them created for the express purpose. The powers of the present small administrative bodies are in many places getting too burdensome for them, and the inevitable tendency must be towards county government, with a system of control over the contained local units. But there can be no distinction between county and county. The county of London, great and powerful, is only, in the English constitution, on a par with the county of Surrey, or of Middlesex, or of any other shire. If it has more powers to commence with, it is only from the accident that more powers had accumulated ready to its hand. Other counties stand upon exactly the same basis, and may administer, either under its direct control or by delegated powers to district councils, whatever Parliament may declare to be local affairs.

A second branch of our summary of the results of an historical examination of the history of county government will help us to grapple with some modern questions. The original land-jurisdiction of the shire-moot in active operation in the 11th century, as we have seen, and the modified land registration which obtained in modern county administration, seem to me to suggest that, at the present time, when we are face to face with a difficulty that has arisen from the emancipation of land from customary local law, we may once more use the county organisation for the registration of land transfers and title to estate, and for the execution of the acts which relate to land allotment. The early control of the county authority over Poor-law, and the modern enactment that county councils may borrow for the purpose of aiding emigration to colonial settlements, seem to me to suggest that Poor-law should be once more a primary county duty; and I may add, in passing, that while there is no legal objection to poor-houses being built beyond the area of the administrating authority, there is no real reason why we should not extend our view of this question altogether, and build up our poor settlements in Burmah or South Africa; for no system of political philosophy will ever allow me to believe that the poor of the great county of London, or elsewhere in the crowded centres of English life, are not superior to the savages who misuse whole tracts of God's earth, because they cannot and will not learn how civilisation has taught the world that 100 acres of cultivated land will do now what in the past of civilised nations it took thousands of acres to do. The modern City of New York, with its million of inhabitants, was once the abode and territory of 400 Indians. The idiosyncrasies of each county which began, as we have seen, in an early tribal state, and which last down to modern times in various forms, seem to me to suggest that the County Council would be the proper authority to whom should be entrusted the care of ancient county monuments, because while I am quite sure that all Wiltshire men would gather together to defend Stonehenge, I am equally certain that Hertfordshire men would have prevented, if they could, the vandalism which has reduced the magnificent structure of St. Alban's Cathedral to a laughing stock; and we have in evidence the anomaly that while the London County Council has power to defend and protect the Egyptian monument, Cleopatra's Needle, it cannot prevent destruction at Westminster Abbey, or it could not resist a proposal to destroy Westminster Hall, a proposal actually made in 1794 by responsible Government architects. It seems to me that the future development of cultured life in England may be aided by the county administration of libraries and museums, and in the preservation and publication of county records, as witness what General Pitt-Rivers has done by his munificent establishment of a museum at Rushmore, which is visited on Sundays throughout the year by the working men of the district in large numbers, and who eagerly try to learn something of the older life which preceded and which governed the direction of their own.

But these and other matters cannot be settled at once. If, as its history indicates, the county becomes the primary unit of local government, it must be the authority to which Parliament must entrust, as a matter of course, all local affairs. Though it could not of itself create new duties, it should decide for itself as to how each new duty declared to belong to local government is to be carried out. There would be no longer any necessity for Parlia-

ment to say, with every fresh enactment of local powers, what particular body should be empowered to carry it out. When once declared to be a local matter, and not an Imperial matter, it should, *ipso facto*, rest with the County Council to arrange for its due performance. One county might think it wise to delegate the powers to district councils, to the parish vestry, to a special body of commissioners. Another county might think it best to perform the duty itself. But the clear thing to keep in mind, as a corollary from the past history of shire government, is that inside the duties declared by Parliament to be attributes of local government, County Councils should have complete control and initiative authority. This at least is due to them as a part of their old and important history. Before this status of the County Council could, however, be absolutely recognised in practice, one very important, and I hold necessary duty, remains to be performed, and here again I think that the history of county government treads closely upon the heels of modern thought. The necessity for the codification of our laws is a subject which has often been talked of. But under the aspect of local government which I have ventured to put forward, it would be necessary to bring about a settlement of what is Imperial and what is local law. The science of jurisprudence has learnt that legal history is the history of the absorption of local custom into national law, until there has been won for the domain of recognised law a magnificent system, which is not unfairly glorified by Edmund Spenser, the poet, as "the just and honourable law of England." Juridical thought must now turn its attention to another domain, and I venture to think that the system of law which will in the future determine a distinct province for local law, will show itself worthy of the county authorities of England, Scotland, and of Ireland. And if the ultimate status of the County Council in the constitution of the Empire be to administer a "just and honourable local law"—the *lex loci* which is so full of the early liberties of our race—England, at all events, will have owed much to its far-famed forty shires.

DISCUSSION.

Mr. W. H. HAYNES said there was a question how far the County Council would affect the duties of the Metropolitan Board of Works, conferred upon it by an Act which had not yet been repealed, and until this Act was repealed, he did not see how the duties of the Metropolitan Board with regard to the erection of new buildings, the appointment of district surveyors, and the support of the Fire Brigade, could be interfered with.

Mr. JOHN LEIGHTON said that one important point brought out in the paper was the unit or base on which the County Council should stand—the concrete foundation. This should be the Vestry, and upon the Vestry should come the County Council, and upon that the Imperial Parliament, with a Senate capped by the chief of the State, which would be the apex. Mr. Gomme said that the many ramifications of our local system utterly confounded the mind of the average elector who sought to take his part in the duties of citizenship. He had had a large experience, both of ladies and gentlemen, knowing little of the office, and less of its requirements, going alone by personal persuasion to the poll, without any conviction whatever, the elector having no official list of the candidates or their qualifications sent to him. He was a candidate in a division where considerably less than half polled. Being for purity of election, he essayed to do without the stump, canvass, or carriage, and the result was that paper and print only secured the intelligent, or about half of the desired number. Doubtless the original vote of the shireman was his upraised hand. We have got beyond that; but the present ballot was cumbersome enough, and did not reach the traveller, the house-tied, or the absentee. Thus half the population failed to exercise an important right, for which there was no remedy but in the post.

Mr. W. SMARTT thought the paper was an admirable one, but that it did not quite indicate what the status of the County Council would be. He had a very strong impression that in the future it would be very similar to the late Metropolitan Board of Works. The wording of the Act was very unsatisfactory, and the whole frame of it so defective that unless an Amendment Act were passed he did not see how a satisfactory result could be attained. The Bill was originally intended to be a local government bill, but it was changed into simply a county government Bill. He himself was qualified to stand for two counties, but not to vote in either, and other anomalies of the same kind could easily be given. It was just the same with the Public Health Act of 1875. He was working with a Sanitary Committee under a Board of Guardians, and there was a constant conflict of authority. In the London County Council all the representatives were on the spot, but in other counties it was different, and his impression was that the representatives would soon get tired of attending, and the result would be that some few men, who might find it worth their while, would attend the meetings regularly and gain great influences, and get measures passed more in the interest of their friends than of the community at large.

Mr. OLIVER J. WILLIAMS said he understood Mr.

Gomme to say that there was nothing analogous to the County Council on the Continent; but in Italy there were provincial councils which were very similar, and he thought it would be very useful if official papers were circulated, stating what were the matters which were dealt with by these Italian provincial councils, and what were left to the central Government. He would ask if there was any mention in history of women having been on any of these councils, or whether history did not show that it was undesirable for women to be members of legislative bodies, however local. Women naturally took a narrower view of things than men who knocked about the world more, and got their views enlarged accordingly. If women had much power in local councils, he feared they would be guided more by sentiment than by reason, and that evil would result. He had not a word to say against women using their legitimate influence, but he did think they should not interfere in those matters respecting which they could not have the experience necessary for public life. The tendency of the County Councils would naturally be towards increased expenditure, and here, again, he did not think women who did not pay rates would be so likely to be economical as men who did.

Mr. H. B. WHEATLEY said the paper covered so extensive a field that he would only venture to refer to one point. He was glad the Legislature had decided that the name should be the County Council, and not the shire council, for he protested strongly against the two words shire and county being considered as synonyms. There were shires which were not counties, and counties which were not shires. He noticed that, although Mr. Gomme used the word shire for certain counties which were not shires, the number of shires in England, given by him at the end of the paper—viz., 40—happened to be the right number for England and Wales, if the counties that were not shires were left out. Doubtless the word county was not used in England before the Norman conquest, but it denoted a certain entity which the shire did not—the shire being merely a division—a something shorn off from something else. Of the 52 counties in England and Wales, there were 40 which were shires and 12 which were not. The Mercian kingdom was divided into 19 shires, and Wessex into six. With regard to those shires which were not counties, he might mention a manuscript of Henry III., where there was a notice of the seven little shires in Cornwall. It might be said that the organisation of the county was the shire organisation, as you had the shire reeve, or sheriff, but he thought the essential idea of the word shire was still borne in mind when the formation of Monmouthshire and the twelve shires in Wales was definitely completed in the reign of Henry VIII., this showing that the idea of the shire as a portion divided off still existed. The kingdom of Kent was not divided into shires but into lathes, and Sussex into rapes, just as the kingdoms of Wessex and Mercia were divided into shires. It was interesting to know that in the reign of Edward I. London was described as a *comitatus*, which looked as if the same idea then existed, as in the present day had caused London to be made into a county. The great interest of the paper lay in showing the value of a knowledge of the past as bearing on the practice of the present and future. Every one would allow that those who knew the successes and failures of the past were more able to deal with the difficulties of the present than those who only knew what was under their eyes.

The CHAIRMAN said this paper was very interesting as an archæological study, and they would all be glad to know that they were returning to the old ways. There was no doubt that the experience of the past ought to rule in the present, and he was glad to find that, in this matter, the latest improvement in local government was so much in accord with what had been found useful in the past, viz., the idea that local people would be best able to understand local matters. He recollected when the Act constituting the Metropolitan Board of Works was passed. Previous to that there were a large number of different bodies controlling the parish roads, and he had in his possession at least twenty-four Acts of Parliament governing the roads in the neighbourhood of London. These were all set aside, and powers were given to the Metropolitan Board which proved very beneficial, and the still greater concentration now taking place was a further advance in the same direction. Of course, the only guarantee of success would be the honourable character of the men who would be engaged; no institution with large powers could be expected to succeed unless that feeling was uppermost in the minds of all. The discussions which would arise, and the sense of responsibility which would be felt by all would, he thought, leave less chance than before of anything improper being done. To what extent the aldermen just elected would influence the Council was yet to be discovered, and he was not quite clear in his own mind what the object of this institution was. He was not sorry to see a lady or two on the Council, for the influence of ladies on public affairs, so far as it had gone, had certainly been advantageous, and he should be very sorry to condemn a system which allowed a woman to sit. As an old member of a City Company, he could say that those companies used to allow women to be associated with them; they were members of the court, and he was not at all sure that the wisdom of our ancestors would not, in this matter, fully justify the wisdom which had been shown on some occasions in calling in the aid of women in modern times. He concluded by proposing a vote of thanks to Mr. Gomme, which was carried unanimously.

Mr. GOMME, in reply, said the probable reason that London was called a *comitatus* in the reign of Edward I. was because it had a very curious and interesting jurisdiction over the county of Middlesex, which, under other circumstances—supposing London to have grown to the north and not to the south as well — might have greatly influenced present legislation. With reference to the difference between shire and county, while he quite admitted the correction of the philological argument, he did not admit the influence of that on the historical argument. Although it was quite true there were both shires and counties, they were both organised on the same plan. His suggestion that the shire organisation was the one now followed was not altered by the fact that, strictly speaking, some of the counties were not shires. In reply to the gentleman who so daringly attacked the ladies, he might say that he knew several instances of ladies holding office in municipal matters; there was a case of a bell-woman and an alderman, but he could not say at the moment where. He did not say there was no analogy to the local council on the Continent, but that there was no analogy between the shire system of England and the Continent. Of course the Continent had local councils, based on some unit or other, but there was nothing like the shire organisation anywhere but in England. That had a strong hold on the public feeling, and that seemed a very good reason for expecting beneficial effects in the future from present legislation. No doubt expenses would increase, but no one wished that London should remain as in 1855, and to produce the London of 1888, money had to be expended. The only means by which one could test whether absence of expenditure was advisable would be to let nothing be done for a series of years, but in the present state of overcrowding he thought that would be impossible.

APPLIED ART SECTION.

Tuesday, February 5, 1889; Major-General DONNELLY, C.B., Vice-President of the Society, in the chair.

A paper on "The Manufacture of Sèvres Porcelain," by Edouard Garnier, late Art-Director of the Sèvres manufactory, was read by Mr. J. Starkie Gardner, who communicated some further notes on Sèvres porcelain.

The paper was illustrated by lantern slides of specimens of Sèvres from the collection of her Majesty the Queen at Buckingham-palace. A service of "Rose du Barry" was exhibited by Mr. George Donaldson, and Messrs. Mintons exhibited a pair of *pâte sur pâte* vases by Mr. Solon, a pair of vases with old Sèvres subjects, decoration and shape, showing the mazarin dark blue, or "Bleu du Roi," the ground the same as the Sèvres, and two pairs of bouquet holders, one showing the Sèvres turquoise blue, and the other the pink or Sèvres "Rose du Barry." All these pieces are of special body, glaze, and colours, and made to obtain the exact feeling and texture of old Sèvres pieces.

The paper will be printed in a forthcoming number of the *Journal*.

Miscellaneous.

PRICKLY PEAR.

The following particulars respecting the prickly pear in Deccan are taken from a letter signed *Indicopleustes*, in *The Times* of February 2. The writer protests against the proposal for the wholesale destruction of the prickly pear in Western India, made in *The Times* of the previous Saturday:—

The species of Opuntian cactus included under the popular name of (West) Indian fig and the Anglo-Indian name of prickly pear are only more unhealthy in the neighbourhood of human habitations than other plants, because the close growth of their flat succulent, pointed stems, branching out in every direction from the crown of the root, makes it more difficult than with ordinary shrubs to keep the ground under them clear of decaying vegetation. But if the ground where it grows is kept clear of its own "off-scourings" the prickly pear is as harmless to man as any other plant; while as a hedge between fields or a fence about farmsteads it is invaluable, being at once impenetrable and uninflammable. These, indeed, were the purposes for which it was originally introduced into the Deccan from Delhi by one of the Sirdars of the old Poona Court—such, at least, is the local tradition—and it must often have proved the salvation of isolated villages from sudden predatory attacks in the time of the anarchy immediately preceding the English occupation of the Mahratta country. Tippoo Sahib is said to have strengthened the defences of Seringapatam by surrounding the fortifications with deep plantations of prickly pear.

Its jointed, juicy, columnar stems form an excellent supplementary fodder for cattle, and it is quite conceivable that a cheap white wine might be manufactured from them in practically limitless measure. It has spread very rapidly throughout Southern India, and chiefly through the agency of birds, which eat greedily of its pyriform fruit, but are unable to digest its hard osseous seeds.

Nothing is easier than the destruction of the plant itself; the native plan in the Mahratta country being

to soak the stems in water for two or three days, the solution obtained forming a good liquid manure. The difficulty in getting rid of the plant, where its extirpation is desired, is entirely due to the hardness of the seeds. But the prickly pear never grows well in rich soils, and when areas where it has spread, while they were left neglected, are once brought under cultivation, it rapidly dies out of itself, as it is unable to face the competition of more civilised plants.

It always thrives most luxuriantly on the barrenest spots, where nothing else will grow, not even a blade of grass; and herein lies the highest usefulness of the prickly pear to all the countries of the Old World into which it has spread, since the 16th century, from the West Indies, Florida, and the Brazils. In the course of 200 years it has covered the barest shelves of rocks all along the desiccated southern and eastern shores of the Mediterranean, from the Atlas mountains to Mount Sinai, and the Taurus range, and by adding *humus* to the soil, restored it gradually to cultivation. On a more restricted scale it has operated in the same way in parts of the Deccan. In short, the prickly pear has proved one of the greatest blessings received by the Old World from America, to which we owe also tobacco, maize, and the potato; and as the potato has helped to bring the heath lands of Central Europe under cultivation, so the prickly pear has served to reclaim from destruction the vast tracts of once arable soil in Northern Africa and Anterior Asia, which, under Mahommedan misrule, had lain denuded and utterly waste and corroded for centuries. I fancy the prickly pear or (West) Indian fig has been prejudiced by the evil significance of the Greek name it bears, which was, however, applied by the Greeks (Theophrastus VI., 4) and Romans (Pliny XXI., 57) to *Cynara Cardunculus*, the "Cardoon;" and Athenæus (II., 83) maintains that *káktos* is but a corruption of *kárdos*. It was called Opuntia from its at one time having been supposed to be the anonymous plant described by Pliny (XXI., 64) as growing near Opus in Locris. But we know that the Greeks and Romans knew nothing of the Opuntian cactuses, and that they are all American species, first described by Oviedo, Matthiolus, Dodonæus, Lobelius, and others in the 16th century A.D., and by Bauhinius, Sloane, and Jacquin in the 17th.

PREPARATION OF RAMIE FIBRE.

(Concluded from page 160.)

"*The Barbier Machine.*—The second machine. known as Barbier's (Décortiqueuse Armand pour la Ramie et toutes les plantes textiles: Constructeur Paul Barbier, Paris), was very similar in construction to the Delandtsheer machine already described. The cost was the same, viz., £40. It was also fitted with a reverse action. The feed plate was horizontal, and the operator handled about 8 to 10 stems at a time, The fibre was somewhat severely bruised in cleaning. In the first trial with dry stems it produced 3·6 kilos per hour of ribbons. With green stems it produced only 7·5 kilos. in 47 minutes. There was a large amount of waste, and owing to the fibre being pushed backwards and forwards between the revolving beaters, the ends were often badly tangled.

"It was claimed by the inventor that this machine could treat 2,500 kilos. of green stems per day of 10 hours, yielding 125 kilos. (presumably of dry) ribbons, worth 50 francs per 100 kilos.

"A machine illustrative of the Systême Lassalle (constructed by H. Chasles, Paris) was on the ground, but it was unable to compete in the trials. For the purpose of this report it may be passed without further notice.

"*Machine of American Fibre Company.*—The next machine was exhibited by the American Fibre Company, of No. 18, Broadway, New York, under the charge of Mr. Noble. This was on an entirely different plan from any of the fibre machines hitherto in use, and deserves a few words of description. The machine was about 4 ft. 6 in. long, and supported on standards about 5 ft. high. Above the machine was a wooden structure designed to receive the moveable frames in which the stems were placed. The feeding was vertical from a frame containing about thirty stems placed above two wooden rollers working horizontally through the whole length of the machine. By means of a moveable bottom in the feeding frame, the stems were dropped base-end downwards between the rollers which slightly crushed them. While firmly held in the machine the stems were pressed against a horizontally moving knife, which split them along their whole length. After this they were bent in such a manner that the woody portions were fractured and separated from the fibrous cuticle. The latter was ultimately delivered in two ribbons, one on each side of the machine. In this instance all that was attempted was to separate the fibrous bark from the stems and deliver the former in broad ribbons, almost intact. No attempt was made to remove the corky epidermis, or separate in any way the constituent fibres. This machine was worked by steam-power, and required three men to attend to it. The cost was not given. It was tried on green stems only, and produced at the first trial seven kilos. of wet ribbons in 18 minutes. At the second trial it produced 12·8 kilos. of wet ribbons in 38 minutes. These results would be equivalent to 21 kilos. of wet ribbons per hour, or allowing one-third of the weight for dry ribbons, equal to about 15 lbs. avoirdupois of dry ribbons per hour. It must, however, be borne in mind that the ribbons produced by this machine were simply the crude fibrous bark without any cleaning. The actual value of these ribbons would be very small, but if the machine had been capable of turning out half a ton, or even a quarter of a ton, of such ribbons in a day, it would have possessed some value. The machine, as shown at Paris, it is

needless to remark, was practically useless for commercial purposes.

"*The Royer Chemical Process.*—The only chemical process for converting ramie ribbons into filasse (or the beautifully white silky threads which ramie is capable of yielding) for textile purposes was shown by M. Royer. This was described by the inventor as 'Degommage de la Ramie Brute,' Systême, E. Royer, Paris. Le traitement industriel complet de la Ramie Brute par ce Systême constitue une dépense de 10 a 12 fr. par 100 kilos. de matière brute.' The details of the process were not made known. The ribbons were laid horizontally in small portable wooden crates, and submitted to the action of certain chemicals in successive baths. Afterwards they were placed in an iron cylinder, or closely-fitting steam chest, and thoroughly exposed to the solvent power of steam at high pressure. The filasse produced was beautifully white in some cases, but in others it was mixed with portions of bark, and discoloured. The system appeared to be laborious and costly. The jury was unable to arrive at a satisfactory conclusion as regards the merits of the process during the session of the trials between the 25th and 30th September, but the general opinion of those present was not favourable to the process.

"The actual trials commenced on the 26th of September and closed on the 30th. The first day was devoted to trials with dry ramie stems, the second to green ramie stems, while the third was chiefly devoted to the chemical process for converting ribbons into fibre. On the fourth day the jury carefully examined the construction of the machines, tested by a dynamo-meter the powers necessary to drive each one, and in some instances retried the machines in order to correct or confirm the results already obtained.

"*Awards of the Jury.*—None of the advertised prizes were given, the jury having only made the following awards, viz.:—600 francs to Mr. Delandtsheer, Paris; 400 francs each to the Compagnie Américane des Fibres, New York, and to Mr. Armand, whose machine was exhibited by Mr. Barbier, Paris.

"These are, briefly stated, the results of the Paris trials on ramie. That the results are unsatisfactory and disappointing, and fall far short of the estimates of the inventors, there can be no matter of doubt. It is probable that a fresh series of trials will be inaugurated next year in connection with the Paris Exhibition of 1889, and if the value of the prizes is increased, there will doubtless appear a larger and better representation of machines and processes.

"*The Favier System.*—It will be noticed that there was no trial this year of the Favier system which is in operation in Spain; nor was there a trial of the Death machine, constructed by Death and Ellwood, of Leicester, which has been in use experimentally in many parts of the world. The Favier process is being worked privately, and is therefore not available to the public. The fibre hitherto produced has been exclusively used in France; but the quantity so far available has not been sufficient to base an opinion as to the permanency of the enterprise. M. Favier, who has long taken a deep interest in the ramie fibre, was a member of the jury at the Paris trials, and the articles which he has contributed on the subject to the *Journal de l'Industrie Progressive*, of October 7 *et seq.*, may be looked upon as embodying the views of one of the best informed of French experts on the present position of the ramie question.

"*The Treatment of Dry as against Green Ramie Stems.*—Amongst the French there is attached an importance beyond their value to machines for cleaning ramie in the dry state. This has arisen partly, no doubt, from the fact that the Favier system, the only one which, hitherto, has obtained a measure of success, requires the stems to be dried before they are treated.

"As regards India and our own colonies, it is essential that ramie machines should work upon the green stems, and not upon the dry. In the rainy season, when the air is impregnated with moisture, to dry ramie stems in the open air after cutting would be an impossibility. To attempt to dry, by artificial means, the enormous quantity of stems yielded even by a few acres, would entail so much labour in handling, and so much expense for buildings and fuel, that it would be altogether a hopeless task.

"The per-centage of crude fibre yielded by ramie stems is estimated at about ten per cent. If the stems must be first dried before they are treated, it would be necessary to handle, to cart in and cart out again from drying sheds, 100 tons of stems for every ten tons of fibre produced. It might be suggested that harvesting the stems should take plaee in the dry season, when the conditions would be most favourable to drying them in the open air.

"This, unfortunately, would not be practicable. The stems grow best during the rainy season, and when once ripe they must be cut at once. Besides, it is evident that the sooner one crop is removed the better will be the prospects of the next. During the dry season the stems grow very slowly, and it has been noticed that such stems have short internodes, are very woody, and offer relatively greater resistance to the process of decortication.

"*Other Processes and Machines.*—Of processes and machines not already mentioned, it is desirable to refer to one or two for the information of persons who may not otherwise become aware of them. In June of last year Mr. C. Maries, of Durbhungah, Bengal, forwarded a series of specimens of ramie fibre in different states of preparation to Kew, and asked for an opinion upon them. It appeared that he had invented a machine, worked by two men in the field, capable of operating upon two to three hundred stems per hour. This machine simply separated the fibrous bark from the wood; the bark was then operated upon by other processes, and

eventually it was deprived of gum and mucilage, and worked into a tolerable fair fibre suitable for manipulation by textile manufacturers. This fibre was reported by Messrs. Ide and Christie as 'long, fairly cleaned ramie fibre worth about £28 per ton.' The particulars of Mr. Maries' methods have not been made public, but we understand that a well-known firm of merchants in Calcutta has acquired the patent connected with them, and the system is now in course of being practically tested on a large scale.

"In the columns of the *Times* there recently appeared an account of a machine invented by Mr. John Orr Wallace, and placed on view at the Irish Exhibition. This was termed a 'patent scutching machine for cleaning ramie, flax, hemp, &c.'

"Small quantities of ramie stems grown at Kew have been successfully passed through the machine. It is proposed by the inventor, when he has completed the alterations, to submit this machine to a public test similar to that adopted at the Paris trials. For this purpose he states that a large supply of ramie stems will be obtained from France.

"There are some special advantages connected with this machine which deserve to be mentioned. In the first place the feed table is so large that at least forty stems can be fed to the rollers at once. When the stems have been fully grasped by the rollers, the operator need not retain his hold upon them any longer. They pass on uninterruptedly through the machine, and they can be followed immediately by a fresh lot without the return action, which is an essential part of the treatment by the Death and the Delandtsheer machines. There is here a considerable saving in time, and there is also a complete absence of the rough usage to which the fibre is subjected in nearly all the purely mechanical processes which have hitherto come under my notice."

General Conclusions.

"An eminent firm of brokers recently informed me:—'There is no doubt that ramie is exciting great interest in many parts of the world, and many people are experimenting with various processes for extracting the fibre cheaply and quickly. We cannot say that any results submitted to us up to the present time are quite satisfactory. The fibre is either imperfectly freed from gummy matter, or the process breaks down in the matter of cost, or owing to the local conditions under which it must be carried on. We consider that no system of preparation which cannot produce the clean, unbleached fibre under £30 per ton is likely to succeed in establishing this article firmly in the estimation of English textile manufacturers.' This opinion expresses very briefly and clearly the conclusion at which I have arrived in connection with the preparation of the ramie fibre. It is quite possible that some machine or process will eventually solve the problem, but the exploitation of ramie, in spite of years of labour and the expenditure of large sums of money upon it, cannot be said to have yet emerged from the experimental stage."

General Notes.

Liverpool Exhibition of Decorative Art.—It is proposed by the Corporation of Liverpool to hold an Exhibition of Art Decoration and Art applied to Manufactures during the months of April, May, June, and July of the present year. The proposed Exhibition will include tapestry, embroidery, wall-papers, ceramics, wood carving and turning, metal wares, bookbinding, and art work in general.

Canadian Mica.—There are four mines of this mineral in Canada, three in Ontario, and one in Quebec. The production in 1886 was 20,361 pounds, valued on the market at 29,000 dollars, or an average of nearly 6s. a pound, but the average for some of the mines is between 6s. 8d. and 7s., showing that much of the mica is of very fine quality. The fact that fine large sheets of mica have a value of several dollars a pound, making in exceptional cases as much as ten dollars per pound for special purposes, has led to popular misapprehension in regard to the average value of this mineral. The quantity of mined and cut during 1887 was 39,500 pounds, and there was also marketed 18 tons of ground mica.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday evenings at Eight o'clock:—

February 13.—"Salt: its Production and Consumption at Home and Abroad." By Peter Lund Simmonds, F.L.S.

February 20.—"The Forth Bridge." By Benjamin Baker, M.Inst.C.E. Sir Frederick Bramwell, Bart., F.R.S., will preside.

February 27.—"The Irish Lace Industry." By Alan S. Cole. The Duke of Abercorn, C.B., will preside

March 6.—"Arc Lamps and their Mechanism." By Prof. Silvanus P. Thompson.

March 13.—"Aluminium and its Manufacture on the Deville Castner Process." By William Anderson, M.Inst.C.E. Prof. Sir Henry Roscoe, F.R.S., will preside.

Foreign and Colonial Section.

Tuesday evenings, at Eight o'clock:—

February 19.—"Slavery in its relation to Trade in Tropical Africa." By Commander V. Lovett Cameron, C.B., R.N. The Earl of Dundonald will preside.

March 12.—"Borneo." By Robert Pritchett.

APPLIED ART SECTION.

Tuesday evenings, at Eight o'clock:—

FEBRUARY 26.—"English Bookbinding in the Reign of Henry VIII." By W. H. J. WEALE.

MARCH 19.—"The Art of the Jeweller." By CARLO GIULIANO.

APRIL 9.—

MAY 14.—"Venetian Glass." By DR. SALVIATI.

INDIAN SECTION.

Friday evenings, at Eight o'clock:—

FEBRUARY 15.—"The Ruby Mines of Burmah." By G. SKELTON STREETER, F.R.G.S. SIR CHARLES E. BERNARD, K.C.S.I., will preside.

MARCH 8.—"The Present Condition and the Prospects of Indian Agriculture." By PROF. ROBERT WALLACE.

MARCH 29.—"The Progress of the Railways and Trade of India." By SIR JULAND DANVERS, K.C.S.I.

MAY 3.—"The Karun as a Trade Route." By MAJOR-GENERAL SIR R. MURDOCH SMITH, K.C.M.G.

MAY 24.—"Indian Wheats." By JOHN McDOUGALL.

CANTOR LECTURES.

The following course of Cantor Lectures will be delivered on Monday evenings at Eight o'clock:—

W. J. LINTON, "Wood Engraving." Two Lectures.

LECTURE I.—FEBRUARY 11.—Wood-engraving in olden time, Babylonian and Egyptian—Its beginning in Europe—Helgen, or Saint-Pictures, and Playing-cards—Early Specimens—Saint Christopher and the Brussels' Virgin—Block-books—The Apocalypsis, Book of Canticles, Biblia Pauperum, Ars Moriendi, and Speculum Humanæ Salvationis—Albert Dürer, his work aud influence on engraving in wood—His Apocalypse, Greater and Lesser Passion, and Life of the Virgin—The Emperor's Arch of Triumph—Jerome Andreæ.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, FEB. 11...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. W. J. Linton, "Wood Engraving." (Lecture I.)
Geographical, University of London, Burlington-gardens, W., 8½ p.m.
British Architects, 9, Conduit-street, W., 8 p.m. Sir Richard Temple, "The Application of Art to Architecture, Indian and other."
Medical, 11, Chandos-street, W., 8½ p.m.
London Institution, Finsbury-circus, E.C., 5 p.m. Mr. Shelford Bidwell, "Some Curiosities of Magnetism."

TUESDAY, FEB. 12...Royal Institution, Albemarle-street, W., 3 p.m. Prof. G. J. Romanes, "Before and After Darwin." II. "Evolution." (Lecture IV.)
Medical and Chirurgical, 53, Berners-street, Oxford-street, W., 8½ p.m.
Civil Engineers, 25, Great George-street, S.W., 8 p.m. Mr. L. F. Vernon-Harcourt, "Some Canal, River, and other Works in France, Belgium, and Germany."
Photographic, 5a, Pall-mall East, S.W., 8 p.m. 1. Annual General Meeting. 2. Mr. J. W. Swan, "Hydrokinone as a Developer."
Anthropological, 3, Hanover-square, W., 8½ p.m. 1. Dr. John Beddoe, "Human Remains discovered by General Pitt-Rivers at Woodcuts, Rotherley, &c." 2. Mr. Bernard Hollander, "A Demonstration of Centres of Ideation in the Brain."
Colonial Institute, Whitehall-rooms, Hôtel Métropole, Whitehall-place, S.W., 8 p.m. Mr. Alfred P. Hensman, "Western Astralia; its Present and Future."

WEDNESDAY, FEB. 13...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. Peter Lund Simmonds, "Salt; its production and consumption at home and abroad."
Graphic, University College, W.C., 8 p.m.
Microscopical, King's College, W.C., 8 p.m. Annual Meeting.
Pharmaceutical, 17, Bloomsbury-square, W.C., 8 p.m.
Entomological, 11, Chandos-street, W., 7 p.m.
Patent Agents, 19, Southampton-buildings, W.C. 7 p.m. 1. Mr. P. Jensen, "On Previous Interfering Patent Applications." 2. Mr. E. Carpmael, "On a recent important decision under the Merchandise Marks' Act, 1887."

THURSDAY, FEB. 14...Royal, Burlington-house, W., 4½ p.m.
Antiquaries, Burlington-house, W., 8½ p.m.
London Institution, Finsbury-circus, E.C., 6 p.m. Prof. Ray Lankester, "Darwin *versus* Lamarck."
Society for the Encouragement of Fine Arts, 9, Conduit-street, W., 8 p.m. Dr. Richardson, Readings from his recent work, "The Son of a Star."—1. The Death of Fidells the Centurion. 2. The Legend of Paradise. 3. The Noviomagians. 4. Israel, behold your King (the Coronation of the Son of a Star). 5. The Holocaust.
Parkes Museum of Hygiene, 74A, Margaret-street, W., 5 p.m. Dr. B. A. Whitelegge, "Notification of Infectious Diseases."
Royal Institution, Albemarle-street, W., 3 p.m Prof. J. W. Judd, "The Metamorphoses of Minerals." (Lecture IV.)
Electrical Engineers, 25, Great George-street, S.W., 8 p.m. 1. Adjourned discussion on Professor A. Jamieson's paper, "The Insulation Resistance of Electric Lighting Circuits." 2. Mr. A. E. Kennelly, "Certain Phenomena connected with Imperfect Earth in Telegraph Circuits."
Mathematical, 22, Albemarle-street, W., 8 p.m.

FRIDAY, FEB. 15...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Indian Section.) Mr. G. Skelton Streeter, "The Ruby Mines of Burmah."
United Service Inst., Whitehall-yard, 3 p.m. Mr. J. Donaldson, "The More Recent Improvements in Thorneycroft Torpedo Boats."
Royal Institution, Albemarle-street, W., 5 p.m. Weekly Meeting, 9 p.m. Prof. A. W. Rücker, "Electrical Stress."
Philological, University College, W.C., 8 p.m. Dr. R. von Fleischhacker, "The Anglo-Saxon Nouns of more than one Gender."
Geological, Burlington-house, W., 1 p.m. Annual Meeting.

SATURDAY, FEB. 16...Royal Institution, Albemarle-street, W., 3 p.m. Prof. Ernst Pauer, "The Character of the Great Composers, and the Characteristics of their Works." With Musical Illustrations. (Lecture IV.)

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FRIDAY, FEBRUARY 15, 1889.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CANTOR LECTURES.

Mr. W. J. Linton delivered the first lecture of his course on "Wood Engraving," on Monday evening, 12th inst. After alluding to the practice of engraving among the Babylonians and Egyptians, the lecturer dealt with the beginnings of wood engraving in Europe. He traced the history of his subject from the Helgen, or Saint Pictures, to the grand works of Albert Dürer, and illustrated his descriptions of the St. Christopher and the Brussels Virgin, of the Block Books, and the works of Dürer, with a series of reproductions, which were thrown upon the screen by means of the lantern.

Proceedings of the Society.

TRIALS OF MOTORS FOR ELECTRIC LIGHTING.

INTRODUCTION.

In the autumn of 1886 the Council of the Society decided to offer some Society of Arts' medals for prime movers suitable for domestic installations for the electric light and other purposes. The details of the proposed competition were carefully considered by the Committee, and in December, 1886, the announcement was made that two gold medals would be offered for prime movers of the class referred to. The classification was intended to include motors of every class, steam, gas, hydraulic, &c. The Council proposed to appoint three judges, who would report to the Council, and on whose report the awards would be made by the Council. The entrance fee was fixed at £2 10s. per h.p., in the hope that the amount derived from fees would suffice to cover a large proportion of the cost. The date fixed for sending in entries was the 28th February, 1887. The entries received by that date were not considered sufficient in number to justify the Society in incurring the necessary expense, and the Council decided to postpone the date for the receipt of entries to the end of December, 1887. Certain alterations were made in the conditions of entry. Four gold and two silver medals were offered under conditions which will be found in an appendix to this report. Notice of this was sent to a large number of makers of engines in this country and abroad. But the result, so far as the number of entries went, was very far from satisfactory. Thirteen entries were contemplated, but only seven entries were actually received, and of these three were withdrawn, so that only four engines were actually presented for trial.

In spite of the paucity of entries (fewer even than in the previous year, when there were eleven) the Council decided to proceed with their experiments. At their request, Dr. Hopkinson, Professor Kennedy, and Mr. Beauchamp Tower, accepted the office of judges, and the trials were successfully carried out in September last, on ground at South Kensington belonging to the Imperial Institute, and kindly lent for the purpose by the Council of that body.

The Council feel that the Society is very greatly indebted to the gentlemen who undertook the office of judges, and who carried out with the utmost care, and the most painstaking accuracy, the arduous duties of that office. They believe that the report which they have prepared will be found to be of great scientific value, and to be well worth the cost incurred by the Society, and the trouble expended on the matter by the Judges and by the Committee; indeed, it is not too much to say that, as regards gas-engines, the experiments are the only thoroughly independent comparative tests of different engines that have been made with any approach to completeness over such long runs, and with such elaborate measurement of all the principal quantities concerned.

The Council have also to express their obligations to the following firms for the free loan of apparatus and fittings:—Messrs. Alex. Wright and Co., standard gas meters (the personal aid rendered by Mr. Richard Wright himself was also most valuable); Messrs. Elwell Parker and Co., two dynamo machines; Messrs. Henry Pooley and Sons,

weighing machines; Messrs. Beck and Co., water meters; Messrs. Frederick Braby and Co., tanks; Messrs. E. Dent and Co., clock. Mr. Humphreys was also liberal enough to erect the iron shed used as a testing house at a very moderate rate. The contractors for the Imperial Institute Building, Messrs. John Mowlem and Co., with their staff, also rendered valuable assistance.

H. TRUEMAN WOOD, *Secretary*.

REPORT OF THE JUDGES.

We have made careful tests of the motors which have been offered for the competition for the Society of Arts' medals.* Finally, only four motors were presented for test, three gas-engines and one steam-engine. The gas-engines were a Crossley 9 h.p. nominal, a Griffin of 8 h.p. nominal, and an Atkinson of 6 h.p. nominal. The steam-engine was a Davey-Paxman compound portable engine of 8 h.p. nominal.

The trials were carried out in a building specially erected for the purpose, on a portion of the site of the Imperial Institute at South Kensington, and were made during September last. The tests comprised an efficiency test during a six hours run for each engine at full power, a three hours run at half power, and a test running light. In addition to these, one or two tests were made at the request of the exhibitors themselves, under conditions varied from the conditions of competition. In the case of the gas-engine tests, the quantity of gas consumed in the engine itself and in the ignition was separately measured, the readings of the meters being taken every quarter of an hour. The meters were Wright's standard wet meters, one of 100, and the other of 20-light size. They were kindly lent to the Society by Mr. Richard Wright, who personally made all the adjustments before the trials, so as to ensure the accuracy of the readings. The pressure and temperature of the gas were measured in the meter, and in each case samples of the gas were taken from time to time, were mixed together for each test, and were analysed by Mr. C. J. Wilson, F.I.C., of University College, London. The results of these analyses will be found in Appendix I., at the end of this report. Indicator diagrams were taken at intervals of a quarter of an hour, the diagrams being taken approximately midway between the times at which the gas was read. The indicator used for the Crossley engine was an improved Richards, made by Elliott and Co., and the same indicator and spring, with another similar one, was used for the Griffin engine. For the Atkinson engine a strengthened Crosby indicator was used. In all cases the indicator springs used have subsequently been tested at University College. The errors being exceedingly small, a correction is not applied in calculating the results given later in respect to each engine. The brake h.p. was in all cases ascertained by means of a rope brake upon the fly-wheel or fly-wheels of the engine. Two ropes were used for each wheel; they were kept at the proper distances apart and in fixed position upon the fly-wheel by means of transverse wooden distance pieces. The dead load was applied by means of weights, and the back tension necessary to put the friction on the brake, by means of a spring balance. The spring balance was read every five minutes, and its tension was deducted from the dead load applied. This brake was found to work perfectly satisfactorily, and its results are certainly beyond suspicion. It is important, however, if any metal be used for attaching the wooden cross-pieces to the ropes, it shall not rub against the rim of the fly-wheel; if this should occur, the metal becomes exceedingly hot, and is liable to burn the rope. The quantity of water used for cooling the cylinder of the engine during the run was measured by means of a Schönheyder water-meter, and its temperature on emergence from the engine was ascertained by a thermometer. The meter was kindly lent to the Society by Messrs. Beck and Co., Limited, and was tested after the trials and found to be without sensible error. The number of revolutions made by the engine was measured by means of a counter continuously geared on to the crank shaft of the engine. This counter was read every quarter of an hour, at the exact instant at which the gas-meter was read.

The efficiency tests of the steam-engine differed slightly from those of the gas-engines. Owing to the greater power developed, and to the smaller size of the fly-wheel of the engine, it would not have been practicable in a continuous run to trust entirely to the cooling of the fly-wheel by the air. The fly-wheel was provided, therefore, with two internal return flanges, which formed a groove the full width of the face of the fly-wheel into which water could be run, which water was continuously evaporated by the heat arising from

* The list of awards was printed in last week's number of the *Journal*, see *ante*, p. 195.

the friction. This arrangement worked very well, and we are of opinion that considerably greater powers could have been measured upon a fly-wheel of this size by this method. The indicator diagrams were obtained, the brake power and the number of turns ascertained in a manner exactly the same as in the case of the gas-engines (the diagrams being taken, however, only every twenty minutes), but instead of measurements of gas and of cooling water, measurements were made of the quantity of coal burnt and of water evaporated. Analyses were made of the coal and also of the furnace gases. In all cases the quantity of lubricant used in the cylinder was measured.

In addition to the efficiency tests of the engines, tests were made to ascertain the regularity of running and of governing. For this purpose the engines were employed to drive a dynamo machine, and the current from this machine was taken through a metallic resistance controlled by switches; an incandescent lamp was also connected to the machine. The amount of cyclic variation occurring in the driving was ascertained by direct observance of the lamp. For electric light motors this is of course a sufficient test, as an engine running so regularly that the variation can not be detected in a lamp may be taken as being perfectly satisfactory for the production of the electric light. The resistances gave a great facility for speedily varying the load upon the engine. The speed of the engine was ascertained when fully loaded, and when running with the dynamo machine upon open circuit; it was also ascertained when running at half power. Observations were made of the effect of throwing off the load as the engine was running, and the hunting of the governor was judged by the pulsations, if any, which ensued in the incandescent lamp.

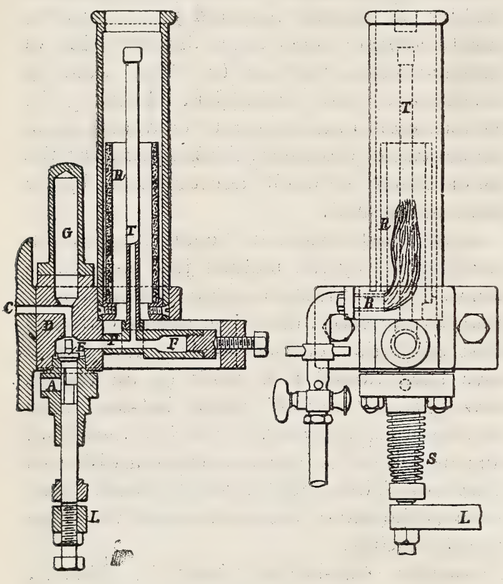
Appended to the account of the experiments on each engine will be found what may be appropriately described as a heat table. In the case of the gas-engines this gives the heat of combustion of the gas, the quantity of this heat accounted for by the indicator diagrams, and the heat carried off by the cooling water. This leaves a balance which will be mainly accounted for by the loss due to the heated exhaust gas, together with a small amouut due to loss by radiation and convection from the surfaces of the engine. If the quantity of the gas and its temperature of exhaust were known, the former and larger of these amounts would be calculable. A very excellent approximation can be made to the quantity of waste gas from the known volume of the cylinder, the only doubtful point being the temperature of the charge when the cylinder is just filled. It is not likely that this temperature will exceed the temperature of the cooling water. Taking this to be the true temperature of the charge immediately before compression begins, the temperature is calculable at which this gas must enter the exhaust to account for the balance. In like manner, in the case of the steam engine, the heat of combustion of the coal is calculated, and this goes partly in heating the furnace gas and partly into the boiler, while in some cases the formation of carbonic oxide reduces the heat actually developed by the combustion. Allowing for the loss due to radiation and convection from the surface of the boiler, the heat entering the boiler should be wholly accounted for by the water evaporated.

As the temperatures in the gas-engines can be estimated by the method just mentioned, and as those in the steam-engine are calculable from the pressures, the trials enable us to say what proportion of the heat received would have been turned into work by an engine working as a "perfect" engine between those temperatures, and, therefore, to find the actual efficiency of the engine as compared with this standard. These figures will be found given below at the end of the details of all the more important trials.

Crossley Gas-engine (sent by Messrs. Crossley Bros., Limited, of Manchester).—This engine is of the ordinary Crossley type, with exceptions to be mentioned. The cylinder was measured and found to be exactly 9·5 inches in diameter and 18 inches stroke. The engine has a single cylinder and is single acting. There are two principal points of divergence from the ordinary type:— First, the arrangement for ignition, and secondly, the use of a counter-shaft for driving the dynamo. Instead of igniting by means of a slide valve, which conveys a portion of the igniting flame to the point at which communication is made to the cylinder, there is a closed igniting tube, marked T in the drawing (Fig. 1), kept hot by a Bunsen flame. It is possible to effect fairly good and regular ignitions by keeping this tube constantly in connection with the interior of the cylinder, and so arranging the length of the tube that the ignitable gas will be forced into it at the right point in the compression stroke. This, however, would be open to the objection that

the time of ignition in the cylinder will vary with the speed of the engine. To render the moment of ignition perfectly definite, Messrs. Crossley have introduced an ignition valve (E) which opens connection between the ignition tube and the cylinder at the right moment. This moment varies with the speed of the engine, In order, then, that the ignition may take place at the correct moment when the engine is fully loaded, and that it shall not occur too soon as the engine is being started, a double cam is introduced upon the shaft

FIG. 1.



DETAILS OF IGNITION VALVE.

C.—Passage to cylinder.

G.—Chamber to receive incombustible contents of passage *C.*

E.—Ignition valve actuated by lever *L.* When *E* is raised by the lever, the peg on *E* enters the hole *D*, and prevents passage of any flame to cylinder, any slight leakage of gas past the peg being then free to pass out at vent-hole *A*, so that there can be no accumulation of pressure in the hot tube until the ignition valve is allowed to descend.

T.—Hot-tube.

R.—Asbestos liner of chimney.

B.—Bunsen burner.

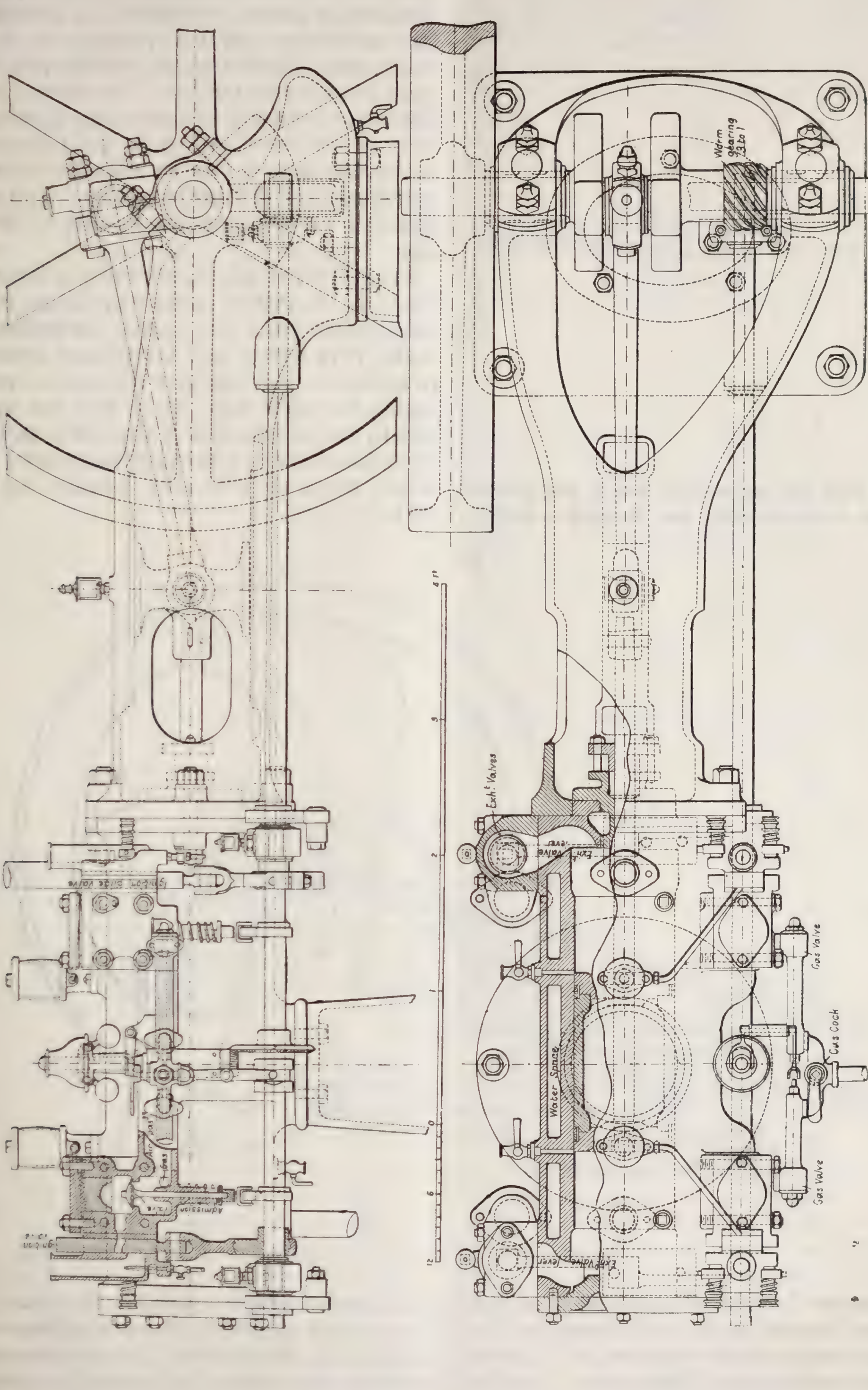
F P.—Easily removed holder for tubes.

which actuates the valve, the one cam is used when the engine is running at its proper speed the other is used when starting. The other special feature of this engine is the use of a counter-shaft with a fly-wheel upon it, running in bearings attached to the engine-bed itself; it is proposed to connect this counter-shaft directly to the dynamo machine to be driven. The intention of this shaft and fly-wheel is, of course, to obtain regular speed of rotation of the dynamo notwithstanding the irregularities of the driving force. The results show that this was perfectly effected, but it was so at the expense of a considerable loss from the slipping of the belt. This slip occurs at the moment when there is greatest tension upon the belt, and, consequently, the loss of power is much more than is represented by the deviation in the speed of the counter-shaft from that which it would have if calculated on the hypothesis of no slip. The engine had one fly-wheel only, 5 ft. $5\frac{1}{2}$ in. diameter, and 9 in. broad on face, weighing 1,652 pounds.

The Griffin Gas-engine (sent by Messrs. Dick, Kerr, and Co., of 101, Leadenhall-street and Kilmarnock).—The Griffin engine is a double-acting engine, which, when working at its full power, ignites the charge at every third stroke at each end of the cylinder. The cycle of the engine at each end of the cylinder is—drawing in gas and air, compressing gas and air, igniting and expanding the charge, ejecting the products of combustion, drawing in scavenger charge of air, and ejecting scavenger charge of air. The ignition is a flame ignition by a slide valve. The general arrangement of the engine and the details of the valve gear are shown in Fig. 2 (p. 217. The cylinder was 9·02 inches diameter and 14·00 inches stroke, with a piston rod 1·75 inches diameter at one end. The governing is effected by omitting the admission of gas whenever the engine is over speed. The engine has two fly-wheels, and an inspection of the speed results show that the governing is effective, and the engine quite free from cyclical variation of speed. The fly-wheels were each 60·1 inches diameter by 7·5 inches broad on face, and each weighed 1,144 lbs.

Atkinson (or "Cycle") Gas-engine (sent by the British Gas-engine and Engineering Company, Limited, Gospel-oak Works).—The Atkinson engine, so far as the connection between the piston and the crank is concerned, differs entirely from either of the other two. During one revolution of the crank shaft the piston performs the following evolutions:—Starting from the extreme back end of the cylinder it advances, drawing in gas and air, it then retires compressing the mixture, but only to a point some distance from the end of the cylinder, the charge is then ignited and the working stroke performed, and lastly the piston retires to the end of the cylinder, ejecting the whole of the products of combustion.

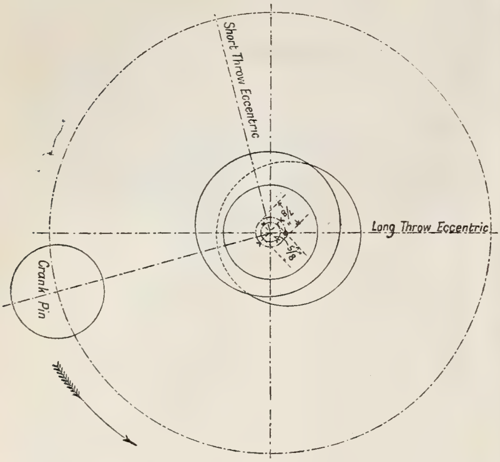
FIG. 2.



GRIFFIN'S GAS ENGINE. (DICK KERR AND CO.)

The general arrangement of the engine is shown in Fig. 4, from which it will be

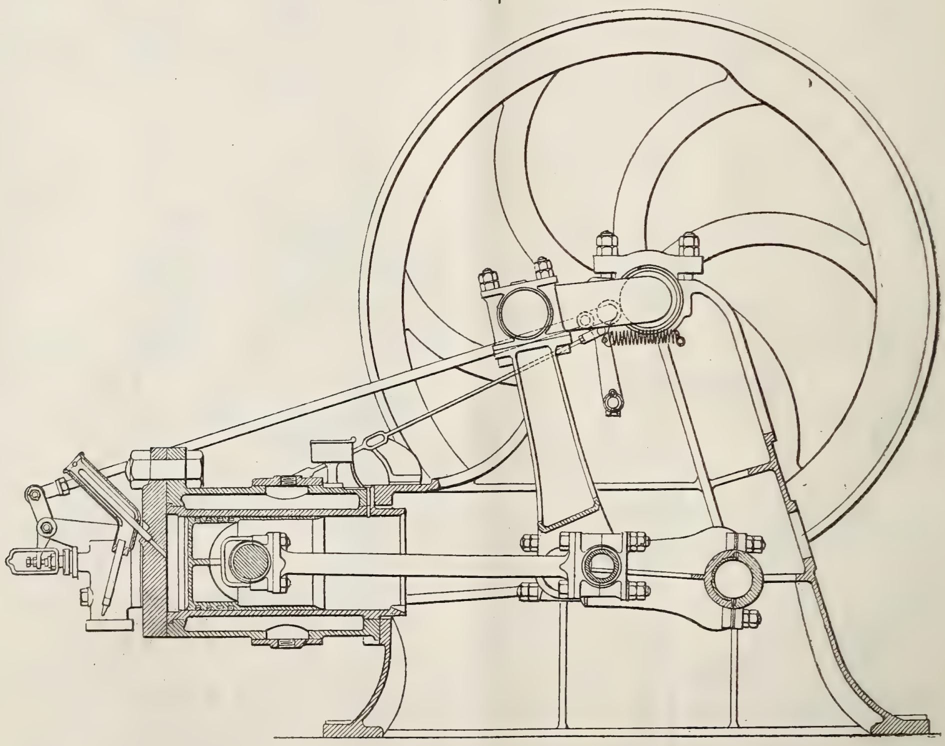
FIG. 3.



seen that the connecting rod is not jointed to the crank directly, but thruogh a toggle-link and rocking-lever, whereby in one revolution of the crank shaft the piston performs two strokes of different lengths. This variation in stroke is effected by jointing the connecting rod, not precisely to the toggle-joint, but to a point upon the link a small distance from the joint. The ignition in this engine is effected by means of an ignition tube, in the same way as in the Crossley engine, but there is here no valve for determining precisely the time of ignition. This is regulated by adjusting the position of the tube.

The cylinder of this engine was 9·50 inches diameter, the suction stroke 6·33 inches, the compression stroke 5·03 inches, the working stroke 11·13 inches, and the exhaust stroke 12·43 inches. The radius of the crank of the engine was $12\frac{7}{8}$ inches. There were two fly-wheels, one on each end of the crank shaft. Each wheel was 69·3 inches diameter and 4·5 inches broad on face, and weighed 1,462 pounds.

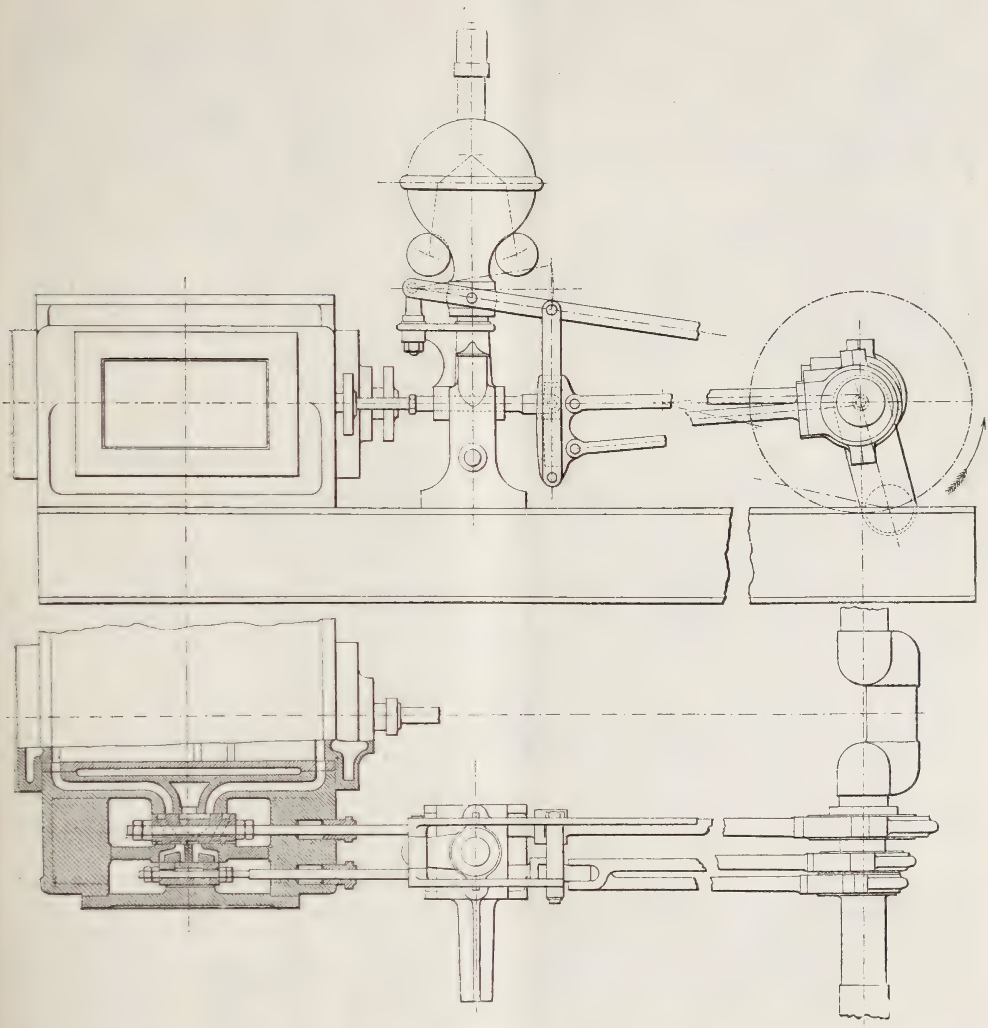
FIG. 4.



Paxman Portable Engine (sent by Messrs. Davey, Paxman and Co., of Colchester).—The general arrangement of this engine is shown in the accompanying photograph. It will be seen that the boiler is of the locomotive type, and that the engine is a compound horizontal, the general arrangement being that well known as adopted by Mr. Paxman. The cylinders are fitted with steam-jackets, which were, however, not used in these experiments. The feed-

water is heated, first, by the exhaust steam in a tubular heater placed upon the top of the boiler, and secondly, by passing through a coil in the smoke-box. The governor acts upon a cut-off valve, through the medium of a link-motion worked by two eccentrics (see Figs. 3 and 5). The diameter of the cylinders is 5·24 and 8·98 inches, and their stroke 14·00 inches. The engine was fitted with one fly-wheel only, 62 inches diameter and $7\frac{3}{8}$ wide, with rim of trough section, as already described. Its weight was 910 pounds.

FIG. 5.



In what follows we have given full particulars of the trials of each engine separately, taking first the full-power trial or trials (lettered A in all cases), then the half-power trial (lettered B), next the trial running empty (lettered C), and lastly, any extra trials that were made by the wish of the exhibitor, or to determine any special points which we thought to require investigation. Each engine has the principal results of all its trials summed up in one Table, and the Tables are arranged so as to be, as far as possible, comparative.

The order in which it has been found most convenient to describe the trials is not exactly that in which the experiments were made, but is—

I. Atkinson.
II. Crossley.
III. Griffin.
IV. Paxman.

ATKINSON GAS-ENGINE.

Five experiments, in all, were made with this engine, and they will be distinguished by the letters A, B, C, D, and E. Trial A was a full-power trial of six hours duration, and trial B a half-power trial of three hours. In trial C the engine ran without load for half an hour. Trials D and E were special short trials with full brake load, but at speeds below the normal. The principal results of these trials are given in Table I.

TABLE I.—ATKINSON GAS-ENGINE.

1	Date	Sept. 21	Sept. 22	Sept. 22	Sept. 24	Sept. 24
2	Trial	A	B	C	D	E
3	Duration	6 hours	3 hours	½ hour	½ hour	½ hour
4	Power	full	half	empty	full	full
5	Revolutions per minute	131·1	129·6	131·9	110·5	100·5
6	Explosions ,, ,,	121·6	69·1	23·8	—	—
7	Mean initial pressure	166·0	166·5	145·5	—	—
8	Mean effective pressure	46·07	47·60	48·59	—	—
9	Indicated H.P.	11·15	6·59	2·3	—	—
10	Brake load nett	130·5	66·0	—	135·4	127·1
11	Brake H.P.	9·48	4·74	—	8·29	7·08
12	Mechanical efficiency	0·850	0·719	—	—	—
13	Gas per hour, main	209·8	127·1	47·2	188·60	157·8
14	,, ,, ignition	4·5	5·9	—	5·42	5·1
15	,, ,, total	214·3	133·0	—	194·02	162·9
16	Gas per indicated H.P. per hour, main	18·82	19·29	20·50	—	—
17	,, ,, ,, ,, total	19·22	20·18	—	—	—
18	Gas per brake H.P. per hour, main	22·14	26·80	—	22·75	22·29
19	,, ,, ,, ,, total	22·61	28·10	—	23·40	23·01
20	Water per hour	680 lbs.	260 lbs.	—	—	—
21	Rise of temperature	52·2°	67·8°	—	—	—
22	H.P. in driving engine	1·67	1·85	2·3	—	—
23	Mean pressure during working stroke, equivalent to work done in pumping strokes, about	1·0	—	—	—	—
24	Corresponding indicated H.P.	0·26	—	—	—	—

TRIAL A. (FIG. 6.)

This trial took place on 21st September, and lasted six hours continuously. Mr. Atkinson elected to run at about 9½ brake h.p., and 130 revolutions per minute. Indicator diagrams were taken every quarter of an hour, and worked out with the number of revolutions made in that interval as read on the counter. The two meters were read every quarter of an hour, and the gas pressure and temperature noted at the same time. The water-meter was also read every quarter of an hour. The spring balances on the brakes were read every five minutes. The work taken up by each of the two fly-wheels was kept as nearly equal as possible. The rope-brakes were worked perfectly dry, without any lubricant whatever.

The mean speed of the engine was 131·1 revolutions per minute. The maximum speed for any quarter hour was 132·7 revolutions per minute, the minimum for any similar period 129·2 revolutions per minute. The number of explosions per minute was 121·6, so that 7·2 per cent. of the explosions were cut off by the governor.

The mean initial pressure was 166 pounds per square inch above the atmosphere, but the mean effective pressure, owing to the great ratio of expansion employed, was only 46·1, the indicated h.p. was thus 11·15. This power is calculated from the revolutions per quarter-hour after deducting the actual number of misses during that time. A record of the actual misses was kept throughout the whole

of this and all the other trials, by two observers, who relieved one another at hourly (or shorter) intervals.

The brake horse-power was 9·48, so that the mechanical efficiency of the engine reached 85 per cent. The horse-power expended in driving the engine (difference between indicated h.p. and brake h.p.) was 1·67.

The gas per hour through the main meter was 209·8 cubic feet, which is at the rate of 18·8 cubic feet per indicated h.p. per hour, and 22·1 per brake h.p. per hour. The addition of the gas used for ignition, 4·5 cubic feet per hour, raises these figures to 19·2 and 22·6 cubic feet respectively.

Diagrams were taken with a light spring to enable some estimate to be made of the power expended by the engine in what have been called the "pumping strokes." Copies of two of these diagrams are given in Fig. 8. The work done during the pumping strokes was equivalent to a mean pressure during the working stroke of about 1·0 pounds per square inch, and this corresponds to an indicated h.p. of 0·26.

The weight of oil used for cylinder lubrication during the six hours was 1·18 pounds. It was a gas-engine oil supplied by the makers of the engine, and costing about 2s. per gallon, or, say, 2·7d. per pound. At this rate, and taking the cost of gas as 2s. 6d. per 1,000 cubic feet, the cost of the cylinder lubrication was equal to that of 1·59 cubic feet of gas per indicated h.p. per hour. The bearings were lubricated with grease, and worked perfectly cool throughout the whole trial.

Analysis of Results.—The measurements made upon this trial, together with the gas analyses of Mr. Wilson, given later on, allow a tolerably complete examination of the working of the engine to be made. In Table II. is given Mr. Wilson's analysis of the gas, which

TABLE II.—ATKINSON TRIAL, SEPT. 21, 1888.

Constituents.	Proportion by volume.	Weight of one cubic ft. At standard pressure and temperature.	Weight in one cubic ft. of gas. At standard pressure and temperature.	Proportion by weight.	Calorific value per lb. down to 100° C.	Calorific value per lb. of gas down to 100° C.	Proportional weight of O required for complete combustion of 1 lb. gas.	Weight of O required for complete combustion of 1 lb. gas.	Weight of products of combustion for 1 lb. gas. Steam.	Weight of products of combustion for 1 lb. gas. Carbonic acid.
	Per cent.	lbs.	lbs.		Thermal units.	Thermal units.		lbs.	lbs.	lbs.
CH_4	37·73	0·0447	0·01686	0·511	21510	10991	4	2·044	1·150	1·405
C_2H_4, &c.	4·07	0·1410	0·00574	0·174	20100	3497	$2\frac{4}{7}$	0·597	0·224	0·547
H	48·56	0·00559	0·00271	0·082	52200	4280	8	0·656	0·738	—
CO	4·19	0·0783	0·00328	0·099	4350	431	$\frac{4}{7}$	0·057	—	0·156
N	4·93	0·0783	0·00386	0·117	—	—	—	—	—	—
CO_2 and O	0·52	0·1060	0·00055	0·017	—	—	—	—	—	—
	100·00		0·03300	1·000		19199		3·354	2·112	2·108

Calorific value of one cubic foot = 19199 × 0·0330 = 633 thermal units.

is by volume, with the corresponding analysis by weight worked out. In the same Table the calorific value of the gas is also worked out. It will be seen that this comes to 19,200 thermal units per pound, or 633 thermal units per cubic foot at standard pressure and temperature.

In order to work out a heat balance for a gas-engine, it is necessary to assume that the various operations have gone on in a certain fashion, to some extent idealised from the actual operations. For this purpose it has been assumed that the indicator diagram of the engine has the form shown in Fig. 10 (p. 227). The points B, C, D, and F have been determined by measurements of the actual pressures in the whole of the indicator cards, and represent the mean of those measurements. The point E has been found by marking a line on each of the indicator diagrams at the mean height of D, and then taking the average distances D E on all the cards. How nearly

this ideal diagram corresponds with the actual one is shown well by the Figure, where one of the actual diagrams nearest to the mean is drawn within it. The pressures and volumes at the cardinal points of the ideal mean diagram are as follow:—

TABLE III.

	Pressure in pounds per square inch. Absolute.	Volume in cubic feet.
A	14·87	0·064
B	14·87	0·324
C	50·30	0·118
D	180·90	0·118
E	180·90	0·135
F	29·00	0·575
G	14·87	0·575

The atmospheric pressure was 14·87 pounds, and the light spring cards showed that the points A, B, and G lay sensibly on the atmospheric line. The meter pressure was 1·48 inches of water, and the temperature of the gas inside the meter 68·8°F. Under these conditions, the weight of gas used per explosion was 0·000896 lb. The temperature of the gas after admission is unknown, but it is not improbable that it was about equal to that of the jacket water when discharged, namely, 116° F. On this assumption, the volume of the gas per explosion would be 0·0314 cubic feet in the cylinder. This assumption as to the temperature of the charge (which has been already alluded to in the introduction) is one which cannot pretend to accuracy, but it is believed to be very near the mark. It should be pointed out that an error of even 20° in this temperature would have a comparatively small effect on any of the following figures, and it is not likely that the error of the assumption made is at all so much as this. The volume of the air under the same conditions would be 0·293 cubic feet, and this corresponds to a ratio of air to gas of 9·33 by volume and 22·8 by weight.

For the purposes of the ideal indicator card it has been assumed that the compression and expansion curves can be represented by equations of the form $pv^n =$ constant. The figure shows that this is a very justifiable assumption. The value of the index n (which in this case, and in all the others given below, has been found by actual measurement of and calculation from the pressures on the whole of the diagrams taken in each trial) for the compression curve is 1·205. The curve, therefore, lies below the adiabatic (which will be sensibly the same as for air, with $n = 1·408$), so that heat must have been rejected to the jacket water during compression. The temperature at the point C would be 719 degrees absolute, and the amount of heat rejected during the compression would be equivalent to 412 foot-pounds.

In the ideal card the main part of the reception of heat is supposed to take place first at constant volume (CD), and then at constant pressure (DE). In most cases the combustion is still incomplete when the expansion begins, and continues as the gas expands. The charge, therefore, goes on receiving heat even during the expansion. The temperature at D works out to 2,620 degrees absolute, and at E, where it reaches its highest value, to 2,990 degrees absolute, or 2530° F. No work is done, of course, during CD. The work done during DE amounts to 435 foot-pounds.

The value of n for the expansion process is 1·264, which, with the volumes given above, corresponds to a fall of temperature of 970°, so that the temperature at F should be 2,020° absolute. The work done during the expansion is 4,280 foot-pounds, but the loss of internal energy corresponding to the fall of temperature is only 3,010 foot-pounds. It is clear, therefore, that a large quantity of heat must have been received by the charge during the expansion; in other words, that combustion must have continued throughout the expansion. More detailed examination of this matter shows that the quantity of heat received per inch of the stroke was about the same towards the end as towards the beginning of the expansion, so that it may fairly be expected that combustion was not completed even when the point F was reached.

One of the essential data for the working out of these problems being the specific heat of the charge, this has been worked out with the results given in Table IV. (p. 223), on the assumption that complete combustion had taken place. The first figures in Table IV. are obtained from those given at the end of Table II.

The nett work per explosion, calculated from the ideal card, comes to 3,390 foot-pounds, from the actual mean indicated h.p. it is 3,030 foot-pounds, or about 89 per cent. of the calculated, which corresponds very closely to the difference between the ideal mean diagram of Fig. 10, and the particular actual card which has been drawn with it.

TABLE IV.

Constituent.	Weight of each pound of coal gas admitted.	Proportions by weight in each pound discharged.	Mechanical equivalent of the heat necessary to raise the temperature one degree Fahr. of			
			One pound (specific heat)		The quantity in one pound discharged.	
			At constant volume.	At constant pressure.	At constant volume.	At constant pressure.
Steam	2·112	0·089	286	371	25·4	33·0
CO_2	2·125	0·089	132	167	11·7	14·9
N	11·217	0·471	134	188	63·1	88·5
Air	8·346	0·351	130	183	45·6	64·2
	23·800	1·000			145·8	200·6

$$200{\cdot}6 - 145{\cdot}8 = 54{\cdot}8 = \kappa$$

$$\frac{200{\cdot}6}{145{\cdot}8} = 1{\cdot}376 = \gamma$$

The jacket water used amounted to 680 pounds per hour, as measured through the meter, and the total heat carried away by it was 33,938 thermal units per hour. This is equivalent to 3,590 foot-pounds per explosion.

The exhaust waste, of which a part, as mentioned below, may go to the jacket water, is practically equivalent to the amount of heat which would bring the charge back from the conditions of pressure, volume and temperature at point F to those at point B. This can easily be calculated, and amounts to 5,030 foot-pounds.

The "Heat Account" for the process, as represented by the ideal mean diagram, stands therefore as follows :—

	Foot-pounds per Explosion.	Per-centages.
Calorific value of the gas used per Explosion 0·000896 × 19200 × 772	13,280	100
Heat turned into work	3,390	25·5
Heat rejected in jacket water	3,590	27·0
Heat rejected in exhaust	5,030	37·9
Heat unaccounted for	1,270	9·6
	13,280	100·0

There seems little doubt that the largeness of the per-centage unaccounted for is due to the fact, already mentioned, that combustion was not completed at the time the point F was reached, so that the charge did not actually receive the whole amount of heat with which it has been credited. A heat account constructed in this way ought, in fact, to *over-balance*, for it cannot be doubted that the jacket water carries off a certain amount of the heat which is here credited to the exhaust, and therefore counted twice over.

The following Table gives the actual per-centages of heat actually turned into work, &c., the heat per explosion being taken as above at 13,280 foot-pounds :—

	Per Cent.
Heat turned into work as shown by indicator diagrams	22 8
Heat rejected in jacket water	27·0
Heat rejected in exhaust, lost by imperfect combustion, and otherwise unaccounted for	50·2
	100·0

The actual expenditure of heat was at the rate of 11,250 thermal units per indicated h.p. per hour, which corresponds to the absolute efficiency of 22·8 per cent. just given. It is very interesting to notice that the heat expenditure per indicated h.p. per hour is little more than half that of the Paxman engine, a difference due, of course, to the greater range of temperature within which the engine works.

The efficiency of the engine, as compared with a perfect engine working between the same limits of temperature, and receiving the same amount of heat, is 28·2 per cent. The limits of temperature assumed are, of course, those which have just been calculated from the ideal mean diagram.

Trial B.

This was a trial at half-brake power, and lasted three hours. The speed was the same as on trial A. The engine ran at 129·6 revolutions per minute, its brake power being 4·74 and its indicated h.p. 6·59 (see Fig. 7), corresponding to a mechanical efficiency of 71·9 per cent. The consumption of gas in the cylinder per indicated h.p. per hour was 19·29 cubic feet, and per brake h.p. per hour 26·8 cubic feet. Taking into account the ignition gas, these figures become 20·18 and 28·10 cubic feet respectively.

The horse-power expended in driving the engine was 1·85.

The expenditure of heat was approximately as follows:—

	Per Cent.
Heat turned into work	22·3
Heat rejected in jacket water	23·2
Heat rejected in exhaust, &c. (by difference)	54·5
	100·0

Fig. 6.

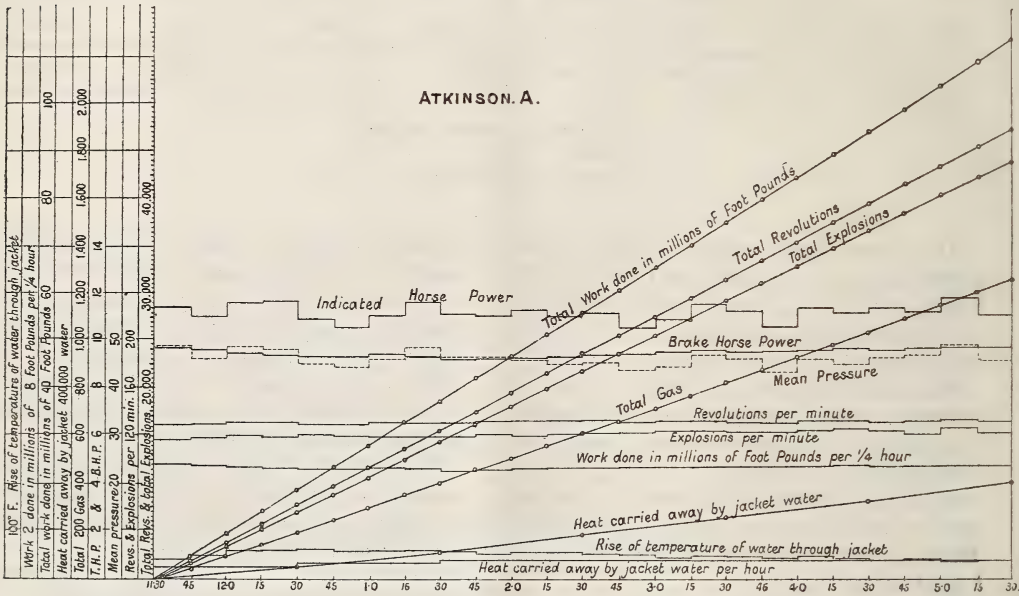


Fig. 7.

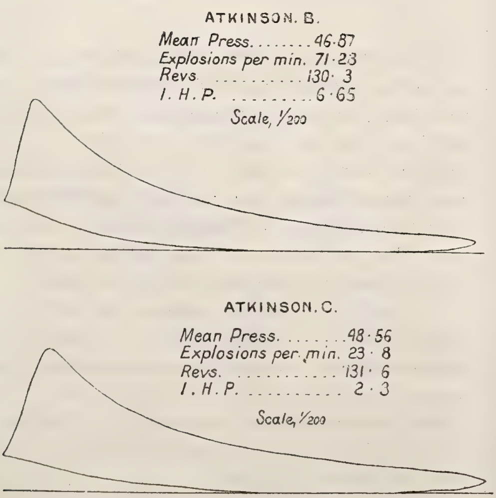
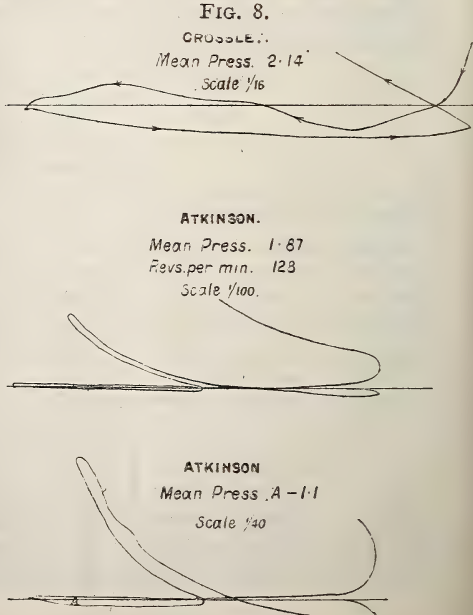


Fig. 8.



Trial C.

In this experiment the engine was run for half an hour empty. Six sets of indicator cards were taken, and give the mean indicated h.p. as 2·3 (see Fig. 7). The gas used in the cylinder per indicated h.p. per hour was at the rate of 20·5 cubic feet. The engine ran at 131·9 revolutions per minute.

The heat turned into work corresponds to 21·0 per cent. of the whole heat of combustion.

It is noteworthy that in this engine the h.p. necessary to drive the engine itself *increases* as the load diminishes, and is much greater when the engine is running empty than when it is loaded. This is doubtless due to the fact that the negative work of the "pumping" strokes (which is given in the Tables, but which has not in any case been deducted from the h.p.), not only becomes proportionately larger because of the increased proportionate number of blank strokes (misses), but also *absolutely* larger per stroke. Working full power, the light spring diagrams (Fig. 8) show that when there is no explosion the charge receives so much heat from the hot end of the cylinder at the end of the compression that in expanding again it does not follow the compression line, but goes considerably beyond it. The diagram for the missed stroke is therefore a double loop, and the area of its positive and negative halves are practically equal. When a number of misses follow one another, as in Trial C, this reception of heat cannot well continue—the positive loop will disappear and the negative one become larger.

Trial D.

In this experiment the engine was run with about the full brake load, but at a lower speed than before, viz., 110·5 revolutions per minute. The brake h.p. was 8·29, and the gas used in the cylinder per brake h.p. 22·75 cubic feet.

Trial E.

On this trial the speed was still further reduced to 100·5 revolutions per minute. The brake h.p. was 7·08, and the gas used in the cylinder per brake h.p. per hour 22·29 cubic feet.

THE CROSSLEY GAS-ENGINE.

Four experiments were made upon this engine—A at full power, B at half power, and C empty (corresponding to the three similarly lettered experiments made with the other engines), and D to ascertain the power necessary to drive the counter-shaft. The principal results of these trials are given in Table V (p. 226).

Trial A (Fig. 11).

This experiment was made on the 19th of September, and lasted six hours continuously. The exhibitors elected to run under 15 brake h.p. and with 160 revolutions per minute. The actual mean brake h.p. was 14·74, and the actual mean speed 160·1 revolutions per minute. The greatest speed during any quarter of an hour was 161·8 revolutions per minute, and the least, 155·1 revolutions per minute. The engine ran quite cool throughout the whole trial. The oil used for cylinder lubrication was Price's gas-engine oil, the value of which is about 3s. 3d. per gallon, or about 4·4d. per pound, and 0·92 lb. was consumed during the run. The value of this lubricant is about equal to that of 1·54 cubic feet of gas per indicated h.p. per hour, taking the gas, as before, at 2s. 6d. per 1,000 cubic feet.

The mean initial pressure was higher than in any of the other engines, being 196·9 pounds per square inch above the atmosphere.

The mean effective pressure was 67.9 pounds per square inch, and the indicated h.p. was 17·12. The indicated h.p, for driving the engine was, therefore, 2·38, and the mechanical efficiency reached 86·1 per cent.

The gas used per indicated h.p. per hour in the cylinder was 20·55 cubic feet, and per brake h.p. per hour 23·87 cubic feet. Taking into account ignition gas, these quantities became 20·76 and 24·1 cubic feet respectively. The work done during the pumping stroke (Fig. 8) was equivalent to a mean pressure of about 2·19 pounds per square inch during the working stroke, which corresponds to an indicated h.p. of 0·55.

The following working out of the thermal efficiency of the engine corresponds to that already given for the Atkinson engine:—

Table VI. (p. 226) gives, as in the former case, an analysis of the gas by weight and the calculation of its calorific value, which amounts to 19,826 thermal units per pound, which corresponds to 626 thermal units per cubic foot under standard conditions. For purposes of calculation the value of the gas has been taken at 19,800 thermal units per pound. It will be noticed that this is somewhat higher than for either of the other two engines, the gas on September 21st being

TABLE V.—CROSSLEY GAS-ENGINE.

1	Date	Sept. 19	Sept. 20	Sept. 20	Sept. 27
2	Trial	A	B	C	D
3	Duration	6 hours	3 hours	½ hour	½ hour
4	Power	Full	Half	Empty	With & without counter-shaft
5	Revolutions per minute	160·1	158·8	161·0	162·3 & 164·8
6	Explosions per minute	78·4	41·1	10·2	19·0 & 10·5
7	Mean initial pressure	196·9	196·2	148·0	—
8	Mean effective pressure	67·9	73·4	66·7	72·3 & 74·1
9	Indicated H.P.	17·12	9·73	2·19	4·40 & 2·50
10	Brake load nett	177·4	89·9	—	—
11	Brake H.P.	14·74	7·41	—	—
12	Mechanical efficiency	0·861	0·762	—	—
13	Gas per hour, main	351·8	202·6	49·0	—
14	,, ,, ignition	3·5	3·2	—	—
15	,, ,, total	355·3	205·8	—	—
16	Gas per indicated H.P. per hour, main	20·55	20 8	22·38	—
17	,, ,, ,, ,, total	20·76	21·2	—	—
18	Gas per brake H.P. per hour, main	23·87	27·34	—	—
19	,, ,, ,, ,, total	24·10	27·77	—	—
20	,, nett H.P. available for electric lighting per hour, after allowing for counter-shaft, as per trial D, main	27·4	36·8	—	—
21	Water per hour	713 lbs.	480 lbs.	—	—
22	Rise of temperature	128·0°	102·3°	—	—
23	H.P. in driving engine	2·38	2·31	2 19	2·50
24	Mean pressure during working stroke, equivalent to work done in pumping strokes, about	2·19	—	—	—
25	Corresponding indicated H.P.	0·55	—	—	—

TABLE VI.—CROSSLEY TRIAL, SEPT. 19, 1888.

Constituents.	Proportion by volume.	Weight of one cubic ft. (At standard pressure and temperature.)	Weight in one cubic ft. of gas. (At standard pressure and temperature.)	Proportion by weight.	Calorific value per lb. down to 100° C.	Calorific value per lb. gas down to 100° C.	Proportional weight of O required for complete combustion of 1 lb. gas.	Weight of O required for complete combustion of 1 lb. gas.	Weight of products of combustion for 1 lb. gas. Steam.	Weight of products of combustion for 1 lb. gas. Carbonic acid.
	Per cent.	lbs.	lbs.		Thermal units.	Thermal units.		lbs.	lbs.	lbs.
CH_4	37·34	0·447	0·01669	0·528	21510	11357	4	2·112	1·188	1·452
C_2H_4, &c.	3·77	0·1410	0·00532	0·169	20100	3397	$2\frac{1}{7}$	0·579	0·217	0·531
H	50·44	0·00559	0·00282	0·089	52200	4646	8	0·712	0·801	—
CO	3·96	0·0783	0·00310	0·098	4350	426	$\frac{4}{7}$	0·056	—	0·154
N	3·98	0·0783	0·00312	0·099	—	—	—	—	—	—
CO_2 and O	0·51	0·1060	0·00054	0·017	—	—	—	—	—	—
	100·00		0·03159	1·000		19826		3·459	2·206	2·137

Calorific value of one cubic foot = 19826 × 0·0316 = 626 thermal units.

FIG. 9.

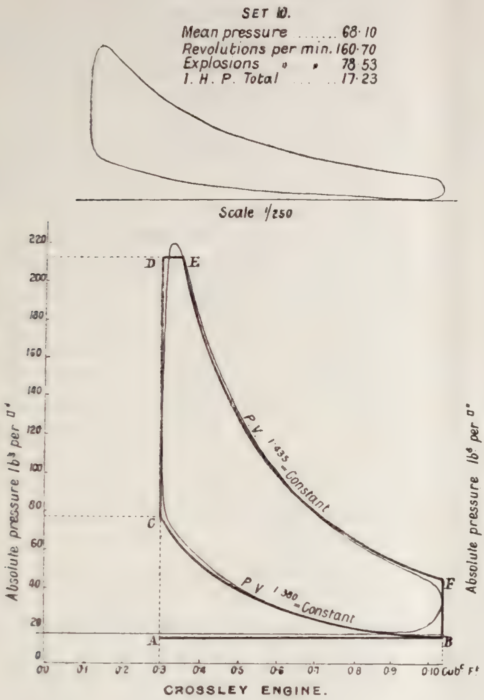


FIG. 10.

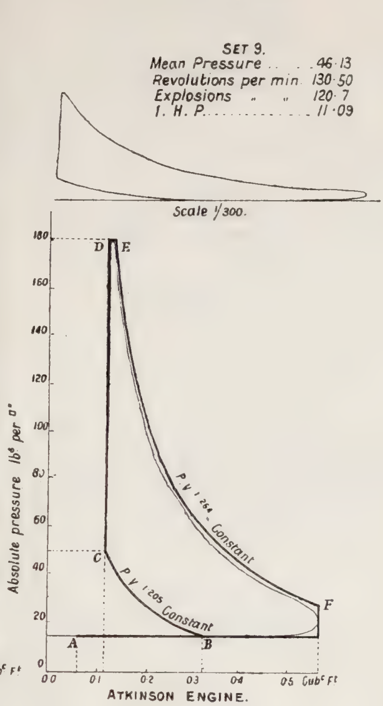


FIG. 11.

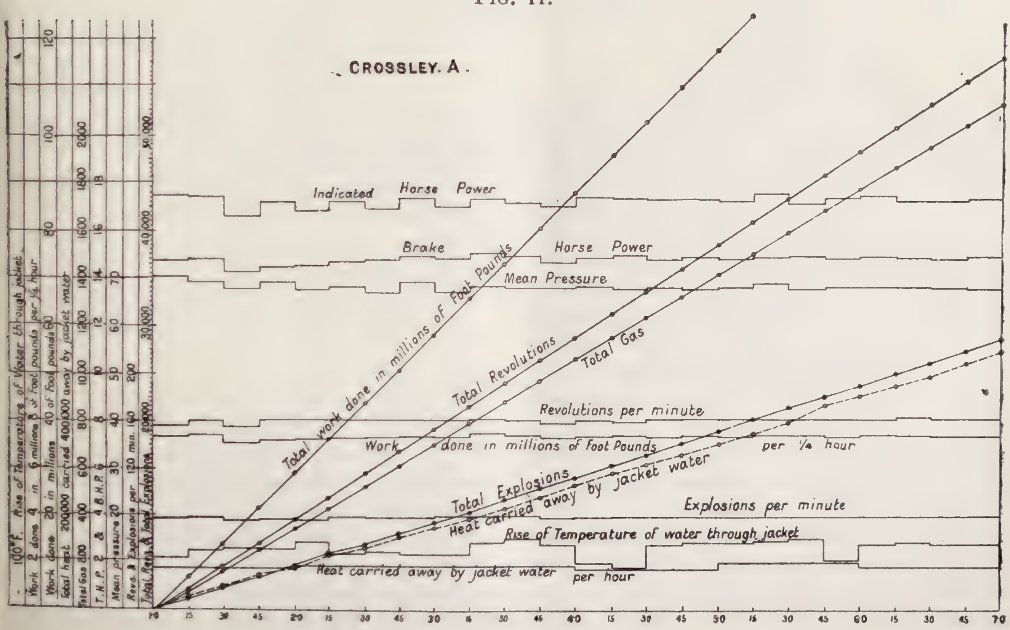
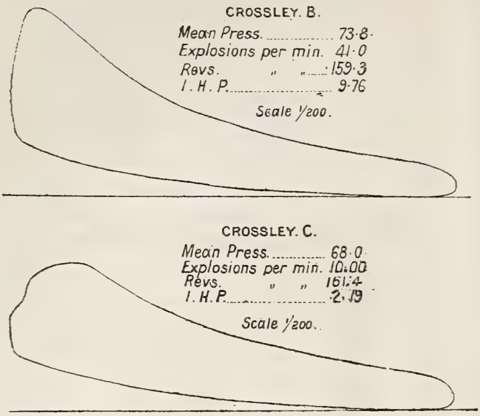


FIG. 12.



of distinctly lower value than on the 19th. The ideal mean indicator diagram, and an actual card for comparison, are shown in Fig. 9. The mean pressures and volumes used for calculation are given in the following Table :—

	Pressure in pounds per square inch. Absolute.	Volumes in cubic feet
A	13·8	0·300
B	13·8	1·039
C	76·3	0·300
D	211·8	0·300
E	211·8	0·3505
F	44·6	1·039

It must be mentioned that the exhibitors were not able to state the precise volume of clearance in this engine as it worked during the trial. It has been taken at 40 per cent. of the volume swept by the piston, which, if not exactly correct, is known to be a close approximation. The barometric pressure for the day was 14·9 pounds per square inch. The temperature of the gas in the meter was 68·2° F., and its pressure 1·34 inches of water.

The total weight of gas per explosion, corrected for these meter conditions, works out to 0·00223 pounds, its calorific value being 34,040 foot-pounds. Assuming, as in the former cases, that the temperature of the charge just before the beginning of compression was equal to that of the jacket discharge water, in this case 190° F, the ratio of air to gas by volume works out to 9·50, and by weight to 24·2, and the total weight of the charge to 0·0561 pounds.

The value of n for the compression is 1·380. The process was, therefore, very nearly adiabatic, only about 6 per cent. of the heat of compression being carried off by the jacket water. The calculated temperature at the end of the compression is 1,064 degrees absolute. The calculated temperature at the point D is 2,950 degrees absolute, and at the point E, where it reaches its maximum value, 3,440° absolute, or about 3,000° Fahr.

The value of n for the expansion process was 1·435, while for the adiabatic process it would be 1·376. The work done during expansion (above zero of pressure) amounts to 9,220 foot-pounds per explosion, while the temperature falls to 2,130° absolute, which corresponds to a loss of internal energy of 10,700 foot-pounds. It appears, therefore, that combustion must have been completed before the expansion ended, and that the gas was losing, and not receiving, heat during its expansion (at least during its latter part), the expansion curve falling much more quickly than the adiabatic line.

It was found that 713·2 pounds of jacket water were used per hour, and that the average amount of heat carried away per hour amounted to 89,575 thermal units, which corresponds to 14,700 foot-pounds per explosion. The calculated value of the exhaust waste is 12,100 foot-pounds per explosion, and with these figures the heat account stands thus :—

	Foot-pounds per Explosion.	Percentages.
Calorific value of the gas per explosion 0·00223 × 19800 × 772	34,040	100
Heat turned into work	7,515	22·1
Heat rejected in jacket water......	14,700	43·2
Heat rejected in exhaust	12,100	35·5
		100·8

The heat account thus overbalances to a small extent. It has been already pointed out that an account calculated in this fashion, although it is the best that seems available, *ought* to overbalance if all the heat be accounted for, because it is inevitable that some of the heat included under exhaust waste, and here supposed to be carried into the atmosphere with the escaping gases, should be taken up by the jacket water, and therefore doubly reckoned above.

The actual indicated work done corresponds to 7,210 foot-pounds per explosion, or 21·2 per cent. of the whole heat of combustion, instead of 22·1 per cent. as above. The heat rejected in the jacket water amounts to 43·2 per cent., and that rejected in the exhaust and unaccounted for to 35·6 of the whole heat of combustion. These quantities agree very closely with those corresponding to the ideal diagram.

The actual heat supplied to the engine amounts to 12,120 thermal units per indicated h.p. per hour, which corresponds to the 21·2 per cent. of absolute efficiency just given. The efficiency of a "perfect" engine working between the same temperatures as those calculated for this engine would be 81·1 per cent. The engine therefore reaches 26·1 per cent. of this efficiency.

Trial B.

This trial lasted 3 hours. The engine ran at half-power (7·41 brake h.p.), at 158·8 revolutions per minute, with 41·1 explosions per minute. The mean initial pressure was practically the same as for trial A, the mean effective pressure somewhat higher (see Table V.). The indicated h.p. was 9·73 (Fig. 12), so that the mechanical efficiency of the engine was 76·2 per cent. The gas used in the cylinder per indicated h.p. per hour was 20·8 cubic feet, per brake h.p. per hour 27·34. Taking into account the gas used for ignition, these figures become 21·2 and 27·77 cubic feet respectively. The horse-power expended in driving the engine amounted to 2·31.

The gas consumed during this trial had a thermal value of about 119,450 thermal units per hour, the expenditure of which was, approximately, as follows:—

	Per Cent.
Heat turned into work	20·9
Heat rejected in jacket water	41·1
Heat rejected in exhaust and unaccounted for (by difference)	38·0
	100·0

Trial C.

In this trial the engine was run for half an hour empty. Cards were taken every five minutes (Fig. 12), and the explosions were counted throughout the whole time as before. The engine ran at 161 revolutions per minute, and made 10·2 explosions per minute. The mean effective pressure was 66·7, and the indicated h.p. 2·19. Gas was used at the rate of 2·38 cubic feet per indicated h.p. per hour.

In this trial the work done corresponds to 19·4 per cent. of the heat of combustion of the gas used.

Trial D.

The Otto engine was fitted, as has been already stated, with a high speed counter-shaft, for the purpose of obtaining greater regularity in driving for electrical purposes. It was thought necessary to find the power expended in driving this counter-shaft as far as it was possible to do so. For this purpose a short trial was made with the engine driving the counter-shaft only. Three sets of indicator diagrams were taken with, and three without, the counter-shaft, and the difference between the powers developed in the two cases may be taken (with the limitation stated later on, p. 245) as representing the power necessary to drive the counter-shaft at its proper speed. The indicated power found necessary to drive the counter-shaft amounts to 1·9 under these circumstances. This indicated h.p. has to be deducted from the brake h.p. of trials A and B, in order to estimate the work which the engine could actually do against electrical resistances. The nett brake horse-power reckoned in this fashion comes therefore to 12·84 and 5·51 respectively, and the corresponding gas consumption per brake horse-power per hour becomes 27·4 and 36·8 cubic feet.

THE GRIFFIN ENGINE.

Four experiments were made upon the Griffin gas-engine. Experiment A was a 6 hours run at full power. Experiment B was a 3 hours run at half power. Experiment C was a short run empty. Experiment D was a one hour's run at a somewhat higher speed and indicated horse-power than trial A, and with an altered valve gear. Particulars of these trials are given in Table VIII.

Trial A (Fig. 13).

This trial corresponds to the similarly lettered trials of the Atkinson and Crossley engines, and observations were made in the same manner. The exhibitors elected to work at 200 revolutions per minute, and at a brake load corresponding to 12½ h.p. effective. The actual average speed throughout the trial was 198·1 revolutions per minute. The maximum speed for any quarter of an hour was 199·8 revolutions per minute, and the minimum 192·7 revolutions

TABLE VIII.—Griffin Gas-engine.

1	Date	Sept. 27	Sept. 27	Sept. 26	Oct. 1
2	Trial	A	B	C	D
3	Duration	6 hours	3 hours	½ hour	1 hour
4	Power	full	half	empty	full
5	Revolutions per minute	198·1	201·8	200·1	206·0
6	Explosions	129·0	82·6	30·6	136·5
7	Mean initial pressure	132·3	135·1	128·0	131·6
8	Mean effective pressure	54·15	55·85	56·60	54·20
9	Indicated H.P.	15·47	10·23	3·84	16·39
10	Brake load, nett	130·7	64·67	—	134·48
11	Brake H.P.	12·51	6·30	—	13·39
12	Mechanical efficiency	0·809	0·616	—	0·817
13	Gas per hour, main	350·2	228·7	95·2	370·8
14	,, ,, ignition	7·1	5·8	4·3	6·98
15	,, ,, total	357·3	234·5	99·5	377·8
16	Gas per indicated H.P. per hour, main	22·64	22·35	24·79	22·63
17	,, ,, ,, ,, total	23·10	22·92	25·91	23·05
18	Gas per brake H.P. per hour, main	28·00	36·30	—	27·69
19	,, ,, ,, ,, total	28·56	37·20	—	28·21
20	Water per hour	1022	616·6	—	—
21	Rise of temperature	71·8°	71·31°	—	—
22	H.P. in driving engine	2·96	3·93	3·84	3·00
23	Mean pressure during working stroke equivalent to work done in pumping strokes (about)	2·40	—	—	—
24	Corresponding indicated H.P.	0·69	—	—	—

TABLE IX.—Griffin Trial, Sept. 27, 1888.

Constituents.	Proportion by volume.	Weight of one cubic ft. (At standard pressure and temperature.)	Weight in one cubic ft. of gas. (At standard pressure and temperature.)	Proportion by weight.	Calorific value per lb. down to 100° C.	Calorific value per lb. of gas down to 100° C.	Proportional weight of O required for complete combustion of 1 lb. of gas.	Weight of O required for complete combustion of 1 lb of gas.	Weight of Products of Combustion for 1 lb. gas. Steam.	Weight of Products of Combustion for 1 lb. gas. Carbonic acid.
	Per cent.	lbs.	lbs.		Thermal units.	Thermal units.		lbs.	lbs.	lbs.
CH_4	36·14	0·0447	0·01615	0·509	21510	10948	4	2 036	1·145	1·400
C_2H_4 &c.	4·04	0·1410	0·00569	0·177	20100	3558	$2\frac{4}{7}$	0·607	0·228	0·556
H	50·94	0·00559	0·00285	0·090	52200	4698	8	0·720	0·810	—
CO	4·58	0·0783	0·00359	0·114	4350	495	$\frac{4}{7}$	0·065	—	0·179
N	3·94	0·0783	0·00309	0·098	—	—	—	—	—	—
CO_2 & O	0·36	0·1060	0·00038	0·012	—	—	—	—	—	—
	100·00		0·03175	1·000		19699		3·428	2·183	2·135

Calorific value of one cubic foot = 19699 × 0·0317 = 624 thermal units.

FIG. 13.

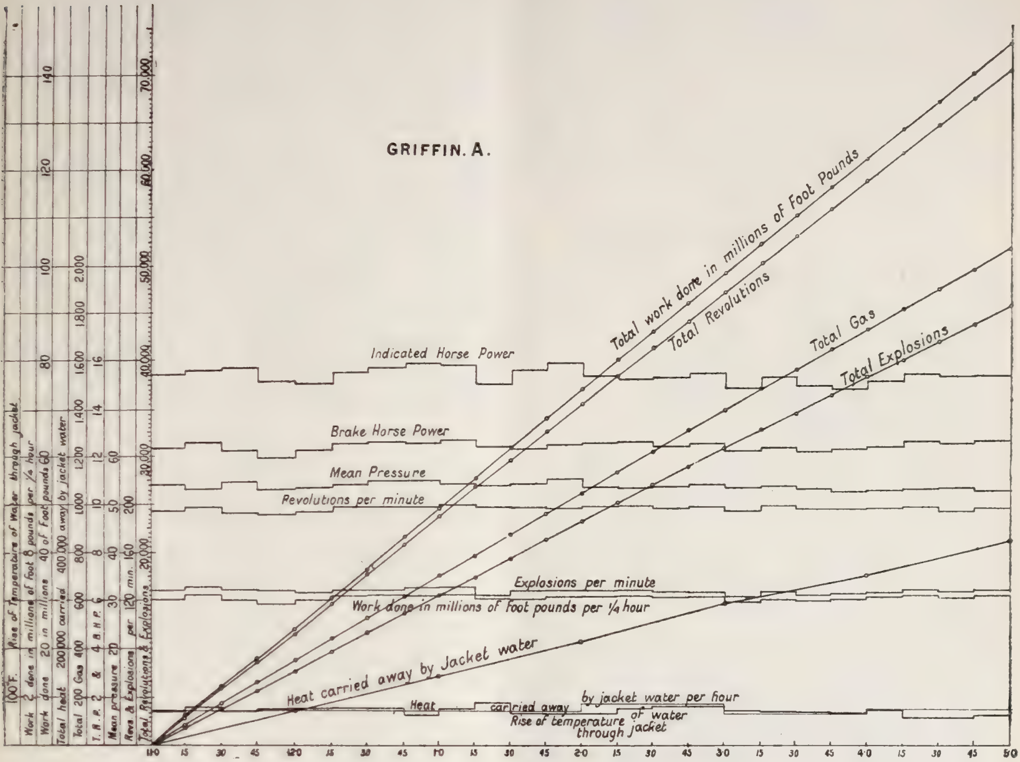

GRIFFIN. A.
Total work done in millions of Foot Pounds
Total Revolutions
Total Gas
Total Explosions
Indicated Horse Power
Brake Horse Power
Mean Pressure
Revolutions per minute
Explosions per minute
Work done in millions of foot pounds per ¼ hour
Heat carried away by Jacket water
Heat carried away by jacket water per hour
Rise of temperature of water through jacket
100°F. Rise of Temperature of Water through jacket
Work done in millions of foot pounds per ¼ hour
Work done 20 in millions 40 of Foot pounds 60
Total heat 200,000 carried 400,000 away by jacket water
Total 200 Gas 400
I.H.P. 2 & 4 B.H.P. 6
Mean pressure 20
Revs & Explosions per 120 min. 160
Total Revolutions & Explosions 20,000
140
120
100
80
2,000
1,800
1,600
1,400
1,200
1000
800
600
16
14
12
10
8
6
60
50
40
30
200
70,000
60,000
50,000
40,000
30,000
1·0
15
30
45
1·20
15
30
45
1·0
15
30
45
2·0
15
30
45
3·0
15
30
45
4·0
15
30
45
5·0

FIG. 14.

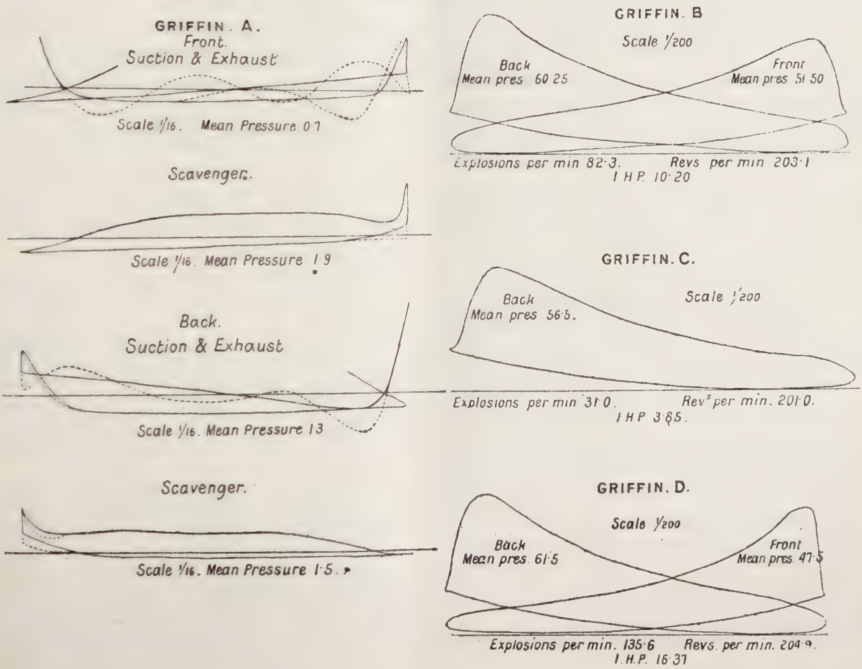
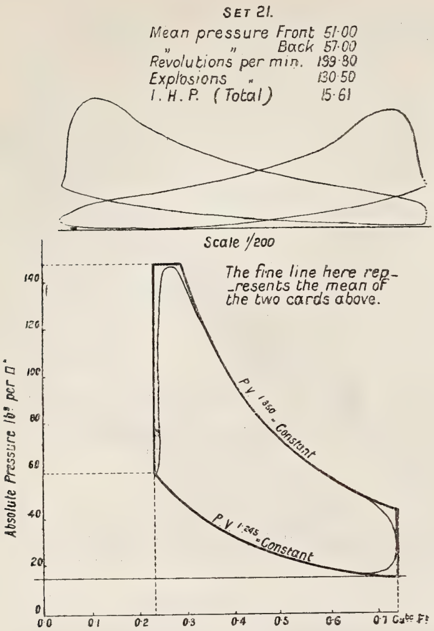

GRIFFIN. A.
Front.
Suction & Exhaust
Scale 1/16. Mean Pressure 0·7
Scavenger.
Scale 1/16. Mean Pressure 1·9
Back.
Suction & Exhaust
Scale 1/16. Mean Pressure 1·3
Scavenger.
Scale 1/16. Mean Pressure 1·5.
GRIFFIN. B
Scale 1/200
Back
Mean pres 60·25
Front
Mean pres 51·50
Explosions per min 82·3. Revs per min 203·1
I.H.P. 10·20
GRIFFIN. C.
Back
Mean pres 56·5.
Scale 1/200
Explosions per min 31·0. Revs per min. 201·0.
I.H.P. 3·85.
GRIFFIN. D.
Scale 1/200
Back
Mean pres. 61·5
Front
Mean pres. 47·5
Explosions per min. 135·6 Revs. per min. 204·9.
I.H.P. 16·31

Fig. 15.



per minute. The average number of explosions (the misses were counted as before) was 129·0 per minute. This corresponds, practically, to three misses per minute. The mean initial pressure was 132·3 pounds per square inch above the atmosphere, corresponding to a mean effective pressure of 54·15 pounds per square inch, and an indicated horse-power of 15·47. The brake h.p. was 12·51, the mechanical efficiency being thus 80·9 per cent., and the power used up in driving the engine itself, 2·96. The engine was fitted with two equal fly-wheels on which similar brakes were placed.

The gas used in the engine was 350·2 cubic feet per hour, and for ignition 7·1 cubic feet. This corresponds to a gas consumption in the cylinder of 22·64 cubic feet per indicated h.p. per hour, or 28·0 cubic feet per brake h.p. per hour. These figures become 23·10 and 28·56 cubic feet respectively, if the ignition gas be also taken into account. The work done during the pumping strokes (Fig. 14), was equivalent to an average mean pressure of 2·40 pounds per square inch throughout the working stroke, and the corresponding indicated h.p. is 0·35. The indicated h.p. expended in driving the engine was 2·96. The engine ran quite cool, and used 1·89 pounds of lubricant in the cylinder (both ends) in the six hours. The lubricant used was "vacuum oil," costing about 3s. per gallon, or 4d. per pound. The cost of cylinder lubrication was, therefore, equal to that of about 2·72 cubic feet of gas per h.p. per hour, taking the gas at the same price as before.

The thermal results of this trial have been worked out upon exactly the same lines as those of the other engines, with the following results:—

The analysis of the gas used is given in Mr. Wilson's report, and its thermal value is worked out in Table IX., which shows it to have been 19,700 thermal units per pound, or 624 thermal units per cubic foot. The weight of the gas used was 0·03175 pounds per cubic foot under standard conditions.

The mean pressures and volumes at the different cardinal points of the stroke marked in Fig. 15 are given in the following Table:—

Table X.

	Pressure in pounds per square inch. Absolute.	Volume in cubic feet.
A	13·8	0·231
B	13·8	0·739
C	58·7	0·231
D	147·2	0·231
E	147·2	0·296
F	42·7	0·739

The mean air temperature for the day was 70° F, the atmospheric pressure being 14·87 pounds per square inch. The temperature of the gas inside the meter was 67° F., and its pressure 1·20 inches of water, its total pressure being thus 14·91 pounds per square inch. The weight of the gas per cubic foot through the meter, under these conditions, works out to 0·0300 pounds per cubic foot. The corresponding weight of gas per explosion was 0·001358 pounds.

The mean temperature of the water as it left the jacket was 132° F., and this has been assumed, as before, to be the temperature of the charge after it entered the cylinder. On this basis the ratio of air to gas by weight works out to 31·6, and by volume to 12·36. The total weight of the charge works out to 0·04426 pounds.

The value of the index n for the compression process, worked out as before, is 1·245, and under these conditions the rise of temperature would be 206° F., so that the temperature at the point C would be 799° absolute. The temperature at D, corresponding to the

rise of pressure at constant volume, would be 2,010° absolute, taking the specific heat of the gas to be the quantity worked out in detail for the Atkinson engine. This is a point in which the different engines would vary extremely little. During the process D E (Fig. 3) the calculated temperature rises to 2,580° absolute, the highest limit of temperature.

The expansion process was very nearly adiabatic, the value of n being 1·350, while for the adiabatic process it would be 1·376. The calculated temperature at F is 1,866° absolute. The quantity of heat apparently received during the expansion is therefore very small. It works out to only 320 foot-pounds, which is less than 7 per cent. of the heat turned into work during the same operation, as against about 30 per cent. in the Atkinson engine. The combustion must, therefore, have been very nearly complete when the point E was reached.

The quantity of jacket water used was 1021·7 pounds per hour, and the average heat carried away by it per hour was 72,790 thermal units. This amount of heat is equivalent to 7,260 foot-pounds per explosion.

The exhaust waste, calculated as before, is equivalent to 8,220 foot-pounds per explosion. With these figures the heat account comes out as follows:—

	Foot-pounds.	Per-centages.
Calorific value of the gas per explosion 0·001358 × 19700 × 772...	20,650	100
Heat turned into work	4,350	21·1
Heat rejected in jacket water	7,260	35·2
Heat rejected in exhaust......	8,220	39·8
Unaccounted for, including heat rejected in blank charge of air.... ...	820	3·9
	20,650	100·0

It is to be noticed that the balance unaccounted for includes in this case a quantity — the heat carried away by the "scavenger" charge of air— which did not exist in either of the two former cases.

The actual work done corresponding to the indicated h.p. of 15·47, was 3,960 foot-pounds per explosion, or 91 per cent. of that due to the ideal mean process. The difference between the ideal mean diagram and an actual indicator card will be seen on reference to Fig. 3. The heat actually turned into work is thus 19·2 per cent. of the whole heat of combustion; 35·2 per cent. of the same quantity was rejected in the jacket water; and 45·6 per cent. in the exhaust, &c. The total quantity of heat used corresponds to 13,390 thermal units per indicated h.p. per hour. The efficiency of a "perfect" engine working between the same limits of temperature as the Griffin engine would be 78 per cent. The efficiency of the actual engine compared with such an engine is 24·6 per cent.

Trial B.

In this trial, which lasted three hours, the brake h.p. was 6·30, or, as nearly as possible, half that upon trial A. All the other conditions were kept as nearly as possible as in trial A. The results are given in Table VIII. The gas used in the cylinder per indicated h.p. per hour was 22·35 cubic feet, and per brake h.p. per hour 36·3 cubic feet. These quantities become 22·92 and 37·2 cubic feet respectively, if the gas used for ignition be also taken into account. The expenditure of the heat of combustion (135,200 thermal units per hour) was approximately as follows:—

	Per Cent.
Heat turned into work	19·4
Heat rejected in jacket water............	32·5
Heat rejected in exhaust and blank charge, and unaccounted for (by difference)	48·1
	100·0

The speed of the engine during this trial was 201·8 revolutions per minute, the number of explosions per minute 82·6, which corresponds to 51·9 misses per minute. The brake h.p. was 6·30, the indicated h.p. 10·23; the mechanical efficiency was, therefore, 61·6 per cent., and the horse-power expended in driving the engine 3·93. The diagrams are given in Fig. 14.

Trial C.

In this trial the engine ran empty. Its mean speed was 200·1 revolutions per minute, with 30·6 explosions per minute, the explosions being in this case counted instead of the misses. The indicated h.p. (mean of six sets of cards, Fig. 14) was 3·84. The gas per indicated h.p. per hour was 24·79 cubic feet, or 25·91 including ignition gas. Running empty, the valves for one end of the cylinder were disconnected, so that the engine worked single-acting.

In this trial the indicated h.p. corresponds to 17·5 per cent. of the whole heat of combustion of the gas used.

Trial D.

During this trial, which lasted for one hour, the engine was run at 206 revolutions per minute. The trial was made for the purpose specially of testing the working of the engine at a somewhat higher speed than before, and with a somewhat different arrangement of valve gear. The mean initial pressure was 131·6 pounds per square inch above the atmosphere. The engine ran with about one governor miss per minute throughout the trial. The indicated h.p. was 16·39 (Fig. 14), and the brake h.p. 13·39, the mechanical efficiency being thus 81·7 per cent., and the horse-power used in driving the engine itself 3·00. The gas used per indicated h.p. per hour was 22·63, and per brake h.p. per hour 27·69, which quantities become 23·05 and 28·21 respectively, taking into account the gas used for ignition.

In this trial the indicated h.p. corresponds to 19·2 per cent. of the whole heat of combustion of the gas used.

PAXMAN COMPOUND PORTABLE STEAM-ENGINE.

Four trials were made of the Paxman engine. The first trial, A_1, was made under conditions as nearly as possible the same as those under which the recent experiments of the Royal Agricultural Society at Newcastle were made on a somewhat similar engine. Coal, indicated horse-power, and brake horse-power were measured throughout, but the whole feed-water was not measured, because a certain quantity of exhaust steam was returned into the tank from which the feed-water was drawn, and the normal conditions under which the engine worked, and under which it was desired that it should be first tested, would not allow this exhaust steam to be weighed. Trial A_2 was of similar duration, and carried out in the same manner, except that no exhaust steam was returned to the feed tank. The total amount of feed-water was therefore accurately known. In both these trials the engine was worked at full power. Trial B was a half-power trial under same conditions as A_2, the whole quantity of feed-water being measured. Trial C was a short trial to ascertain the indicated horse-power required to run the engine at full speed empty. The principal results of these trials are shown in Table XI.

Trial A_2 (Fig. 17).

In discussing these results we shall commence with the trial A_2, as being really the most important of the trials made. This trial took place on September 28th, and its duration was about six and a quarter hours. The trial began and ended with the engine running, and start and finish were conducted in the following manner:—

The steam pressure, revolutions, and brake load being all those at which it was intended to work throughout the trial, and the ash-pan being cleaned out, the fire was reduced until the pressure fell notably, and then stoking was commenced from the weighed coal. In this case the pressure fell to 150 pounds per square inch before it began to rise again. When the whole of the weighed coal had been used, and the ashes, as far as possible, put upon the fire again, the trial was declared at an end when the pressure again fell to that at which the trial started. The speed of the engine was the same at the commencement and finish, and the height of the water in the gauge glass was also the same. It is thought, therefore, that the error due to any difference between the amounts of fuel on the grate at beginning and end must be reduced to a minimum. The fuel used was supposed and stated to be "Powell's Duffryn" coal. From the analysis, however, given in Mr. Wilson's report, as well as from our experience of the behaviour of the coal, it was certainly not up to the standard which is expected from that coal, and it contained only 84 per cent. of carbon. The total amount of coal weighed out was 255 pounds. It was weighed on a tray placed upon the platform of a weighing machine, so that the amount put upon the fire in each half-hour could be accurately known. It will be seen from the diagram that the stoking was very regular throughout. The steam pressure and height of water in glass were read every ten minutes throughout the trial. The mean steam pressure was 188 pounds per square inch over the atmosphere, the atmospheric pressure being 14·8 pounds per square inch. The trial lasted 6 hours 16 minutes, or 6·27 hours. Six samples of furnace gas were collected. The analyses of these samples are given in Mr. Wilson's report. The temperature of the chimney gases was read every five minutes; the chimney draft was also taken at frequent intervals. For measuring the temperature of the chimney gases a mercury thermometer was used, the space above the mercury being filled with nitrogen under pressure, so that the thermometer could be employed without fear of accident above the normal boiling point of mercury. It will be seen, however, that there was no

TABLE XI.—PAXMAN ENGINE.

1	Date	Sept. 26	Sept. 28	Oct. 1	Oct. 1
2	Trial	A1	A2	B	C
3	Duration	6·43 hours	6·27 hours	3·12 hours	½ hour
4	Power	Full	Full	Half	Empty
5	Revolutions per minute	140·48	137·35	138·10	144·20
6	Mean initial pressure, high-pressure cylinder	176·6	176·8	113 0	—
7	Mean ratio of expansion				
8	Mean effective pressure, high-pressure cylinder	52·93	54·98	33·25	11·32
9	,, ,, ,, low-pressure ,,	17·56	16·78	8·92	– ·19
10	Indicated H.P. effective pressure, high-pressure cylinder	11·14	11·30	6·85	+2·40
11	,, ,, ,, ,, low-pressure ,,	10·98	10·26	5·47	–0·12
12	,, ,, Total	22·12	21·56	12·32	2·28
13	Brake load nett	288·8	288·0	147·6	—
14	Brake H.P.	19·44	18·95	9·76	—
15	Mechanical efficiency	0·879	0·879	0·792	—
16	Indicated H.P in driving engine	2·68	2·61	2·56	2·28
	Boiler.				
17	Mean boiler pressure (above atmosphere)	191·35	187·98	120·10	—
18	Atmospheric pressure for the day	14·9	14·8	14·8	—
19	Boiler pressure (absolute)	206·25	202·78	134·9	—
20	Temperature of boiler steam	384·3°	382·9°	350·1°	—
21	Pounds of feed used per hour	[448·7]	447·1	392·2	—
22	,, ,, ,, indicated H.P. per hour	[20·28]	20·74	26·72	—
23	,, ,, ,, brake H.P. per hour	[23·08]	23·59	33·73	—
24	Mean temperature of feed-water in tank	63·0	63·0	69·9	—
25	,, ,, ,, before entering coil	[201]	201	—	—
26	,, ,, ,, ,, exhaust feed-heater	115·7	63·0	—	—
27	Temperature of chimney gases (Fahr.)	355·4°	304·4°	369·1°	—
28	Coal per hour	39·66	40·70	27·25	—
29	,, ,, per indicated H.P.	1·79	1·89	2·21	—
30	,, ,, per brake H.P.	2·04	2·15	2 79	—
31	Pounds of water per pound of coal	—	10·99	12·08	—
32	,, ,, ,, ,, from and at 212° F.	—	11·71	12·76	—

occasion for this precaution with this particular engine. For feed-water measurement a large tank, which contained sufficient water to last throughout the whole trial, was placed upon the platform of a 50 cwt. weighing machine, carefully adjusted. An india-rubber pipe from this tank led the water to a small open tank beside the engine, from which the feed-tank drew its supply. This tank was also placed upon the platform of a weighing machine. The steelyard of the large weighing machine was arranged so as to make a contact and ring an electric bell every time it fell down on its lower stop. Each time this happened the weight on the steelyard was reduced by one hundredweight, so that the steelyard at once lifted, and only again fell when another hundredweight of water had been used. In this way the exact times at which each hundredweight of water passed out of the large tank could be noted. By noting at the same moment the weight of water in the small tank, the amount of feed-water which had gone into the boiler was exactly known. The temperature of the feed-water in the small tank was noted at frequent intervals; it was, of course, simply the temperature of the water in the mains, and so was practically constant. In the Paxman engine, as has been already stated in the earlier

part of this report, the feed-water before going to the boiler passes first through a feed-heater, which is in point of fact a kind of surface condenser for the exhaust steam, and then through a coil of pipe in the smoke-box, by which its temperature is still further raised. A thermometer was placed in the closest possible contact with the feed-pipe between these two feed-heaters, its bulb being carefully wrapped round with a large thickness of non-conductor. This thermometer was read every five minutes throughout the trial, and it is believed that its readings give a very close approximation of the temperature to which the feed-water was raised by the exhaust steam. The temperature at which the feed-water actually enters the boiler proper, after having passed through the feed-heater coil in the smoke-box, could not be measured.

It will be seen from the Table that the mean temperature of the feed-water, after leaving the exhaust feed-heater, was 201° F., although its initial temperature was only 63° F. As the temperature of the exhaust steam could not have been sensibly above 212° F., it will be seen that this feed-heater is in itself so efficient that there is no necessity for actually returning any condensed steam into the feed-tank to heat the water before it goes to the feed-heater. The weight of condensed steam which would otherwise have gone to the feed-tank was measured separately.

Indicator cards (Fig. 18) were taken three times per hour, in the middle of each interval of twenty minutes. The counter was read every twenty minutes, having been set to zero at the start, and the indicated h.p. of each set of cards was computed from the revolutions corresponding to the interval within which that set was taken. The mean indicated h.p., 21·56, is given in the Table. The minimum h.p. for any set of cards was 21·2, the maximum 22·2. The mean revolutions per minute were 137·4, the minimum for any twenty minutes 135·9, the maximum 140·2.

Four Crosby indicators were used, a separate indicator on each end of each cylinder, with the shortest possible pipes to the cylinder. The steam jackets were not used during the trial, Mr. Paxman electing to run without them. The rope-brake employed has been already described. The spring-balance was read every five minutes throughout the trial. The weight on the brake was altered a little from time to time, so as to keep the net brake resistance as uniform as possible. Throughout the greater part of the trial the weight was about 320 pounds, the spring-balance reading being about 32 pounds. The brake h.p. was 18·95. The fly-wheel rim was of trough section, and water was allowed to drip into it and evaporate away. No lubricant of any kind was employed on the surface of the brake. The amount of water run into the rim was about 0·65 pounds per minute at full power, which if evaporated at 212° corresponds (the water temperature being 62°F.) to 725 thermal units per minute, or the equivalent of 17 brake h.p., which is nearly 88 per cent. of the whole power taken up by the engine. This figure, however, is certainly somewhat too high, as a small, but not insensible, quantity of water was lost by splashing.

The thermal results of the trial work out as follows, commencing with the furnace and boiler:—

The calorific value of the coal is about 14,200 thermal units per pound.* The fuel used per hour during the trial was 40·7 pounds, and we have, therefore, to account for 577,900 thermal units per hour. This heat is expended in (*a*) heating and evaporating water, (*b*) heating coal and furnace gases, (*c*) heating surrounding objects by radiation, (*d*) evaporating the moisture in the coal; and these points will be considered in order.

(*a*) *Heating and evaporation of water.*—The total feed-water per hour was 447·1 pounds, its temperature on entering the coil in the chimney—that is when it began to receive heat from the furnace gases—was 201° F. The steam temperature was 383° F. The total heat taken up by each pound of water under these conditions would be 1,029·6 thermal units. The total heat, therefore, expended usefully in the boiler per hour was 460,300 thermal units, or 79·7 per cent. of the whole heat of combustion, and this fraction represents the actual boiler efficiency.

(*b*) *Heating coal and furnace gases.*—The following figures give the mean of Mr.

* In this assumption no deduction is made from the hydrogen on account of oxygen already present in the fuel and shown by its analysis. Although this deduction is so commonly made, it does not seem to be founded on any clearly defined basis, for it is quite certain that in whatever form the hydrogen may exist in the fuel, that form is *not* one of simple combination with oxygen as H_2O. Practical determinations of the calorimetric value of fuel, moreover, appear always to give figures in excess of that found by calculation when the hydrogen which would combine with the oxygen is deducted. The calorific value of the hydrogen is taken at 52,200 thermal units per pound, which corresponds to the production of *gaseous* and not *liquid* water in the furnace gases. There is, therefore, no correction to be afterwards made for the latent heat of the steam in the furnace gases.

Wilson's analyses of the furnace gases during this trial, and also the corresponding composition of the gases by weight:—

TABLE XII.

	Per-centage Composition of Chimney Gases.	
	By Volume.	By Weight.
CO_2	11·86	17·21
CO	0·56	0·52
O	7·27	7·67
N	80·31	74·60
	100·00	100·00

It was attempted to determine the moisture in the gases also, but this was found to be quite impossible, because of the amount of exhaust steam close to the place from which the gases were collected. The analyses given are, therefore, of dry gas. By comparing the weights of nitrogen and carbon in the gas, it will be found that the amount of air used works out to 19·74 lbs. per pound of carbon. As 1 lb. of coal contained only 0·84 lbs. of carbon, the weight of air per pound of coal must have been 16·68, so that the weight of the whole furnace gases must have been very closely 17·7 lbs. for each pound of coal. The air temperature in the testing house was 65°F. The mean chimney temperature (measured *above* the heating coil) was only 304° F.; the rise of temperature of the furnace gases being, therefore, 239° F. The mean specific heat of the gases was about 0·237. The amount of heat expended in raising their temperature was, therefore, 40,700 thermal units, or 7·1 per cent. of the whole heat of combustion.

(*c*.) *Radiation.*—An endeavour was made to determine this loss by a separate experiment. Steam having been got up, and everything being in its normal condition, as nearly as possible, the fire was drawn and small quantities of coal put on from time to time, just sufficient to prevent the pressure from falling, The total quantity of coal burnt amounted to 13·5 pounds in 3 hours 23 minutes, or four pounds per hour. Some unknown proportion of this quantity was no doubt expended in heating air and furnace gases passing up the chimney. It may probably be taken as a fair approximation that about the same proportion of heat was employed in heating the furnace gases and lost otherwise as in the run when the engine was working, *i. e.*, 9·9 per cent, leaving a balance of 90 per cent, lost by radiation. We may, therefore, take it that 90 per cent. of four pounds, or 3·6 pounds per hour approximately, represents the quantity of coal corresponding to the losses by radiation. In default of any more accurate means of

FIG. 16.

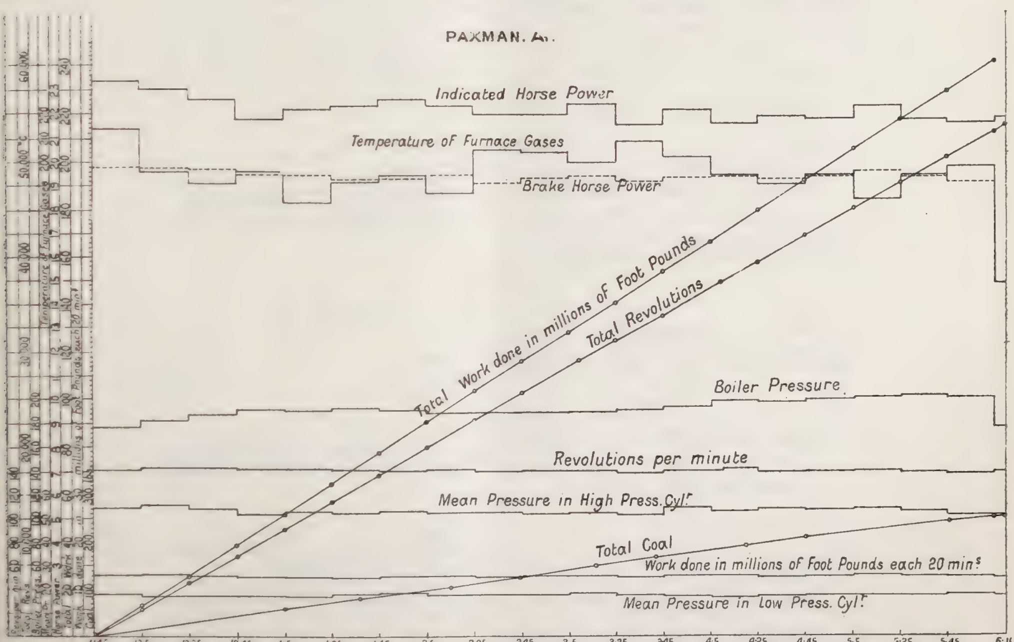


FIG. 17.

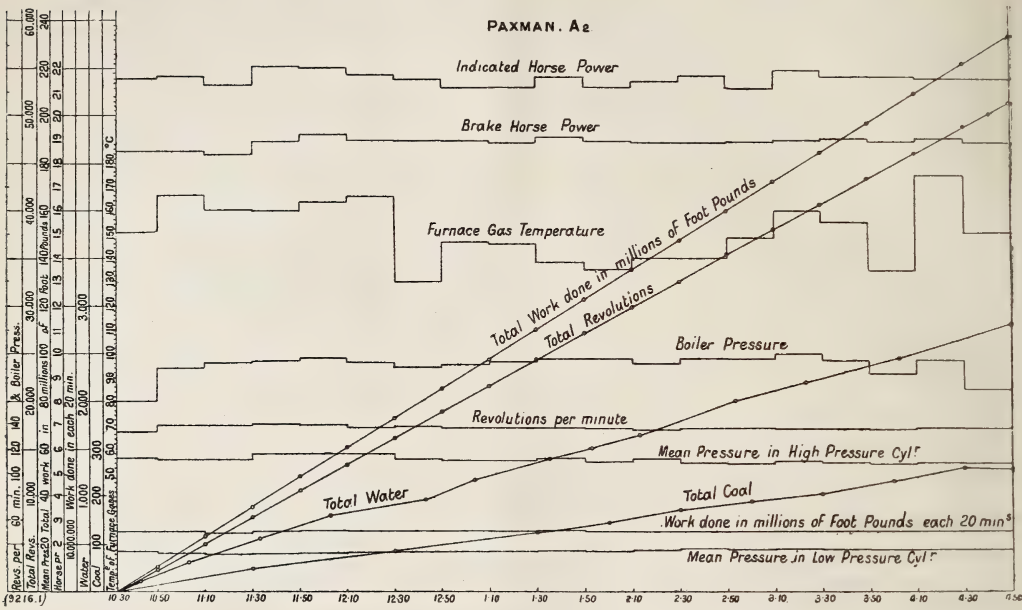

PAXMAN. A2
Indicated Horse Power
Brake Horse Power
Furnace Gas Temperature
Total Work done in millions of Foot Pounds
Total Revolutions
Boiler Pressure
Revolutions per minute
Mean Pressure in High Pressure Cylr
Total Water
Total Coal
Work done in millions of Foot Pounds each 20 mins
Mean Pressure in Low Pressure Cylr
Revs. per 60 min. 100 120 140 & Boiler Press.
Total Revs. 10,000 20,000 30,000 40,000 50,000 60,000
Mean Pres 20 Total 40 work 60 in 80 millions 100 of 120 Foot 140 Pounds 160 180 200 220 240
Horse pr 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
10,000,000 Work done in each 20 min.
Water 1,000 2,000 3,000
Coal 100 200 300
Temp. of Furnace Gases 50 60 70 80 90 100 110 120 130 140 150 160 170 180 °C
(9216.1)
10 30 10 50 11 10 11 30 11 50 12 10 12 30 12 50 1 10 1 30 1 50 2 10 2 30 2 50 3 10 3 30 3 50 4 10 4 30 4 50

FIG. 18.

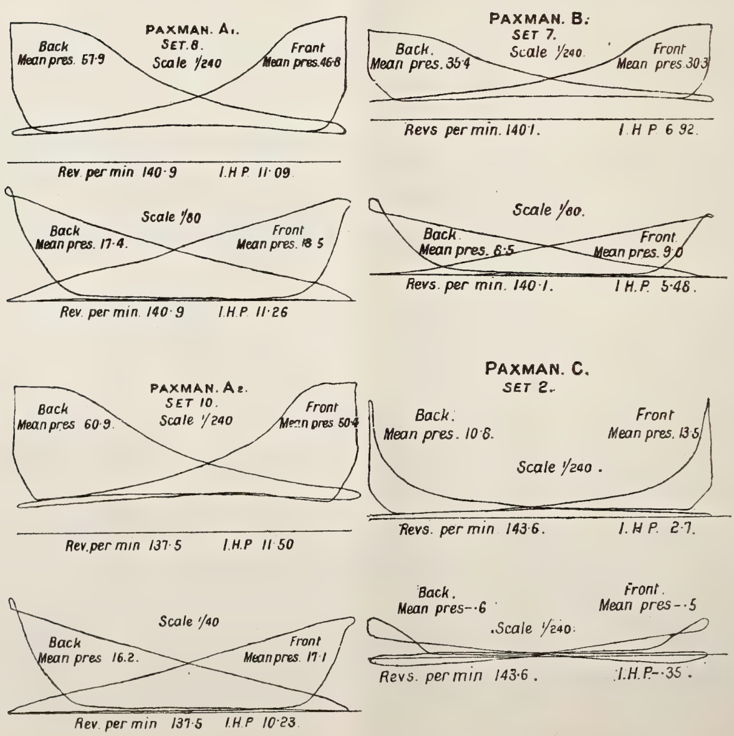
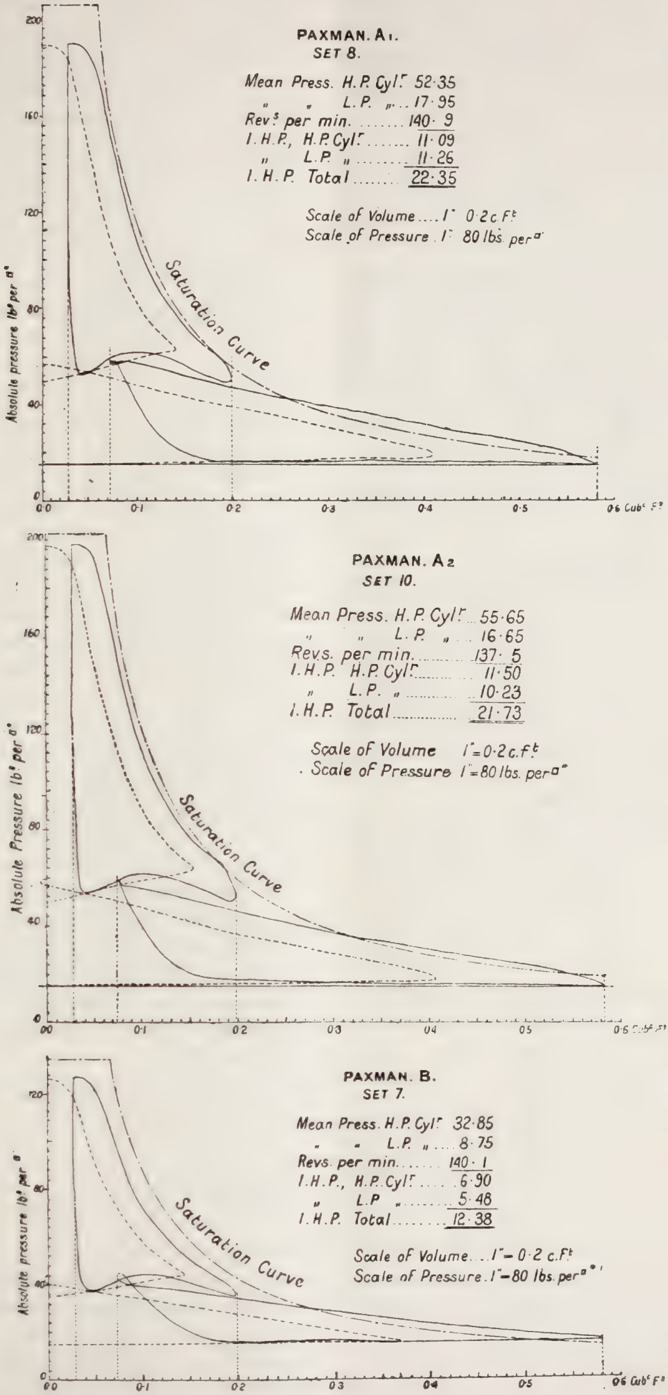

PAXMAN. A1.
SET. 8.
Scale 1/240
Back
Mean pres. 57·9
Front
Mean pres. 46·8
Rev. per min 140·9
I.H.P. 11·09
Scale 1/80
Back
Mean pres. 17·4.
Front
Mean pres. 18 5
Rev. per min. 140·9
I.H.P. 11·26
PAXMAN. B.
SET 7.
Scale 1/240
Back.
Mean pres. 35·4
Front
Mean pres. 30·3
Revs per min. 140·1.
I.H.P. 6 92.
Scale 1/80.
Back.
Mean pres. 6·5
Front.
Mean pres. 9·0
Revs. per min. 140·1.
I.H.P. 5·48.
PAXMAN. A2.
SET 10.
Scale 1/240
Back
Mean pres 60·9.
Front
Mean pres 50·4
Rev. per min 137·5
I.H.P. 11·50
Scale 1/40
Back
Mean pres 16.2.
Front
Mean pres. 17·1
Rev. per min 137·5
I.H.P. 10·23.
PAXMAN. C.
SET 2.
Back.
Mean pres. 10·6.
Front
Mean pres. 13·5
Scale 1/240.
Revs. per min 143·6.
I.H.P. 2·7.
Back.
Mean pres--·6
Front.
Mean pres--·5
Scale 1/240.
Revs. per min 143·6.
I.H.P.--·35.

FIG. 19.


PAXMAN. A1.
SET 8.
Mean Press. H.P. Cylr. 52·35
" " L.P. " .. 17·95
Revs per min. .... 140· 9
I.H.P., H.P. Cylr. .... 11·09
" L.P. " .... 11·26
I.H.P. Total .... 22·35
Scale of Volume .... 1" 0·2 c. Ft.
Scale of Pressure . 1" 80 lbs. per □"
Saturation Curve
Absolute pressure lbs. per □"
200
160
120
80
40
0
0·0
0·1
0·2
0·3
0·4
0·5
0·6 Cubc Ft.
PAXMAN. A2
SET 10.
Mean Press. H.P. Cylr. .. 55·65
" " L.P. " .. 16·65
Revs. per min. .... 137· 5
I.H.P. H.P. Cylr. .... 11·50
" L.P. " .... 10·23
I.H.P. Total .... 21·73
Scale of Volume 1"=0·2 c.ft.
Scale of Pressure 1"=80 lbs. per □"
Saturation Curve
Absolute Pressure lbs. per □"
200
160
120
80
40
0
0·0
0·1
0·2
0·3
0·4
0·5
0·6
PAXMAN. B.
SET 7.
Mean Press. H.P. Cylr. 32·85
" " L.P. " .... 8·75
Revs. per min. ...... 140· 1
I.H.P., H.P. Cylr. ..... 6·90
" L.P. " .... 5·48
I.H.P. Total .... 12·38
Scale of Volume ...1"= 0·2 c.Ft.
Scale of Pressure. 1"=80 lbs. per □"
Saturation Curve
Absolute pressure lbs. per □"
120
80
40
0
0·0
0·1
0·2
0·3
0·4
0·5
0·6 Cubc Ft.

determining this quantity, it must be assumed that the loss by radiation when the engines are running is the same as when they are stopped, the steam pressure and other conditions being the same. We may, therefore, say that, approximately, 3·6 pounds of coal per hour, with a value of 51,075 thermal units, or about 8·9 per cent. of the whole heat of the combustion was lost through this cause.

(d.) Evaporation of Moisture in Coal.—The evaporation of the 1·21 per cent. of moisture in the coal corresponds only to 570 thermal units per hour, or 0·1 per cent. of the total heat of combustion.

Loss by formation of Carbonic Oxide.—An examination of the gas analysis by weight shows that 4·48 per cent. of the carbon was burnt only to CO instead of to CO_2. It will be found that this corresponds to a loss of about 380 thermal units per pound of coal, or 15,450 thermal units per hour, which is 2·68 per cent. of the whole heat of the combustion. The whole heat account for the boiler stands therefore thus:—

TABLE XIII.

	Thermal Units.	Percentages.
Calorific value of 40·7 pounds of coal	577,900	100
Heat expended in heating and evaporating water, including heat given up by gases to coil in chimney	460,300	79·65
Heat expended in raising temperature of furnace gases	40,700	7·05
Heat lost by radiation	51·070	8·85
Heat lost by imperfect combustion	15,450	2·68
Heat expended in evaporating moisture in coal	570	0·10
Heat lost in ash and otherwise unaccounted for	9,810	1·67
	577,900	100·0

One very notable point about these results is the extremely low temperature of the chimney gases, considerably below that of the steam in the boiler. This is obviously due to the very efficient action of the coil in the chimney as a feed-heater. There was no possibility of measuring the temperature of the feed water as it left the coil and entered the boiler. If the furnace gases left the tubes at a temperature of about 400° F.—and they could hardly be cooler—they must have been reduced in temperature by the coil about 100° F. As there were 1·16 pounds of furnace gases for each pound of water, and as their respective specific heats are 0·237 and 1·00, 100 degrees fall in the temperature of the furnace gases would correspond to about 38 degrees rise in the temperature of the water.

The steam which was condensed in the feed heater was collected and measured. It amounted to 63·8 pounds per hour. Taking each pound to have given up simply its latent heat at atmospheric pressure (and with feed at 201° F., it could hardly do more), this corresponds to 61,640 thermal units per hour. The heat taken up by the feed water, 447 pounds per hour raised from 63° to 201° F., amounts te 61,690 thermal units, which differs from the quantity just given by an amount far within the limits of accuracy of the measurements.

The water actually evaporated per pound of coal was 10·99 pounds. This was raised from 201° to 383° F. and evaporated at the latter temperature. Reduced to evaporation from and at 212°F. the figure becomes 11·71 pounds. Perhaps a still better standard for comparison with other engines may be obtained by taking the evaporation per pound of carbon-value in the coal. The weight of carbon in each pound of coal was 0·845 pounds. The hydrogen in the coal was equivalent to 0·131 pounds of carbon, so that each pound of coal had a calorific value equal to that of 0·976 pounds of carbon. The water evaporated under standard conditions per pound of carbon-value was therefore just 12 pounds. It is assumed that the steam was *dry*, and that there was no priming. There was no indication whatever of priming, but probably the best evidence of its absence is the closeness of the heat balance in Table XIII.

Engine.—The work done, 21·55 indicated h.p., corresponds to 55,300 thermal units per hour, or 12·0 per cent. of the whole heat taken up by the water. The efficiency of a perfect heat engine working between 383 and 212° F. would be 0·205. Such an engine receiving the same amount of heat as the Paxman engine, namely 460,300 thermal units per hour, would turn into work 93,200 thermal units per hour. The actual efficiency of the engine therefore, compared with such a perfect engine, is 59 per cent. The heat received by the engine per indicated h.p. per hour was 21,350 thermal units.

The brake h.p. of the engine was 18·95; its mechanical efficiency was therefore 87·9 per cent., the indicated h.p. expended in driving the engine itself being 2·61.

Boiler and Engine.—The combined efficiency of the furnace, boiler and engine, as represented by the consumption of fuel per horse-power, works out to 9·6 per cent., 55,300 thermal units being turned into work per hour, with an expenditure of fuel having a value of 577,900 thermal units. The coal used per indicated h.p. per hour was 1·89 pounds, and per brake h.p. per hour 2·15 pounds.

Steam by Indicator Cards.—The amount of steam shown by the indicator diagrams (Figs. 18 and 19) has been measured at two places, with the following results:—

	Per-centage of whole weighed feed-water.
Steam in h.p. cylinder at a pressure of 150 lbs. per square inch above the atmosphere, which corresponds to a point at 0·39 of the stroke, a little after cut off in all cases	65·0
Steam in l.p. cylinder at a pressure of 10 lbs. per square inch above the atmosphere, which corresponds to a point at 0·67 of the stroke, well before release in all cases	78·8

TRIAL A_1. (FIG. 16.)

This trial took place on the 26th of September, and was nominally of the same duration as trial A_2. As already mentioned the engine was tested in its normal condition of working, with condensed steam from the feed-heater added in unknown amount to the feed-water. The boiler was stoked by Mr. Paxman himself. Speed, brake-power, boiler pressure, &c., were all nominally the same as in trial A_2, the small differences between them being fully given in Table XI. The same amount of coal was used, but it kept the engine going with somewhat larger indicated h.p., namely 22·1, for 6 hours 26 minutes, or ten minutes longer than in trial A_2. The brake h.p. was 19·4, so that the mechanical efficiency was again 87·9 per cent. The coal used per hour was 39·7 pounds, which corresponds to 1·79 pounds per indicated h.p. per hour, and 2·04 pounds per brake h.p. per hour. Worked out per pound of carbon-value in the coal (see p. 240, *ante*) these figures become 1·75 and 1·99 respectively. It may be noted in passing that the coal used on the Newcastle trials was of distinctly better quality than the coal here employed. Measured in the same fashion each pound of coal there used was equivalent to 1·015 of a pound of carbon, instead of 0·976, and had therefore a heating value nearly 4 per cent. in excess of the coal used in these trials.

As the added feed was not directly measured it cannot be expected that it would be possible to obtain a complete heat balance from this trial. It is possible, however, to obtain one in which the error must be very small. The actual quantity of feed-water supplied from the weighed tank amounted to 407·5 pounds per hour. This quantity was raised from 63° to 115·7° F. by the addition mainly of condensed steam from the feed-heater. From various measurements made during the trial, it is possible to calculate (the details of the calculation need not be given) the amount of condensed steam added to the weighed feed. It must have been very closely 41·2 pounds per hour, making the total feed-water 448·7 pounds per hour. In the following account of the heat disposed of in the boiler (Table XV.) this quantity is taken as correct. Calculations similar to those made for Trial A_2 show that the quantity of air used per pound of coal was 20·8 pounds, so that, approximately, 21·8 pounds of furnace gases passed up the chimney for each pound of coal put on the fire. The complete analyses of the furnace gases are given in Mr. Wilson's report, and a summary of them is given in Table XIV.

TABLE XIV.

Constituent.	Per-centage by volume.	Per-centage by weight.
CO_2	9·98	14·60
CO	0·00	0·00
O	9·70	10·30
N	80·32	75·10
	100·00	100·00

It will be seen that on no occasion was any carbonic oxide found to be present. The mean chimney temperature was 355° F., which, although higher than in Trial A_2, is still less than the temperature of the steam, owing no doubt, as before, mainly to the action of the coil as a feed-heater.

The error of *plus* 1·6 per cent. is, perhaps, not more than might be expected for a calculation in which one important item has had to be estimated.

Taking as correct the quantity of feed-water per hour given above, namely, 448·7 pounds,

TABLE XV.

	Thermal Units.	Per-centages.
Calorific value of 39·7 pounds of coal (the quantity used per hour)	564,000	100
Heat expended in raising 448·7 pounds of water from 201° to 384° F., and eveporating it at that temperature..................	462,000	82·0
Heat expended in raising temperature of furnace gases	59,400	10·5
Heat lost by radiation (as before) .	51,070	9·0
Heat expended in evaporating moisture in coal (as before)	570	0·1
		101·6

the feed-water per indicated h.p. per hour was 20·28 pounds, and per brake h.p. per hour 23·88 pounds, results a little better than those of trial A_2. On the same basis, the heat turned into work is 12·26 per cent. of the whole heat taken up by the water in the boiler, which is just 60 per cent. of the quantity which would be turned into work by a "perfect" steam-engine working between the same temperatures, and receiving the same amount of heat per hour. The heat taken up by the water amounts to 20,850 thermal units per indicated h.p. per hour, as against 21,350 thermal units in trial A_2.

The steam shown by indicator cards (Figs. 18 and 19) as present in high pressure and low pressure cylinders respectively, at the pressures already given (see trial A_2), amount to 65·0 and 80·2 per cent., respectively, of the weighed feed-water.

TRIAL B

This trial took place on October 1st. Its nominal duration was three hours, and its object to test the working of the engine at about half its full brake power. It has not been thought necessary to work out the thermal results of this trial in so much detail as those of the full power trial. The speed of the engine was 138·1 revolutions per minute, and brake h.p. 9·76, or almost exactly half of the brake power of the former trials. The weight of fuel used was 85 pounds, and the trial lasted 3 hours 7 minutes.

The mean boiler pressure was kept lower than before, namely at 120·1 pounds per square inch, in order to avoid an extremely early cut off. The quantity of feed-water was completely measured as in trial A_2. It amounted to 329·2 pounds per hour, and the coal per hour having been 27·25 pounds, the evaporation per pound of coal was 12·08 pounds. Reduced to standard, this amounts to 12·76 pounds per pound of coal, or 13·09 pounds per pound of carbon-value. The mean temperature of the chimney gases was 369·1° F.

The indicated h.p. on this trial was 12·32 (Figs. 18 and 19), so that the mechanical efficiency of the engine reached 79·2 per cent. working at half-power. The indicated h.p. expended in driving the engine itself, that is, the difference between the indicated h.p. and the brake h.p., was 2.56 as against 2·61 and 2·68 in trials A_2 and A_1 respectively, the revolutions having been very nearly the same in all three cases.

TRIAL C.

This was a short experiment of half an hour's duration, to determine the power necessary to run the engine alone without any load. The speed was 144·2 revolutions per minute, the indicated h.p. 2·32. The trial lasted half an hour, and six sets of indicator cards (Fig. 18) were taken in that time. In nearly all of these the power shown on the low-pressure cards was negative.

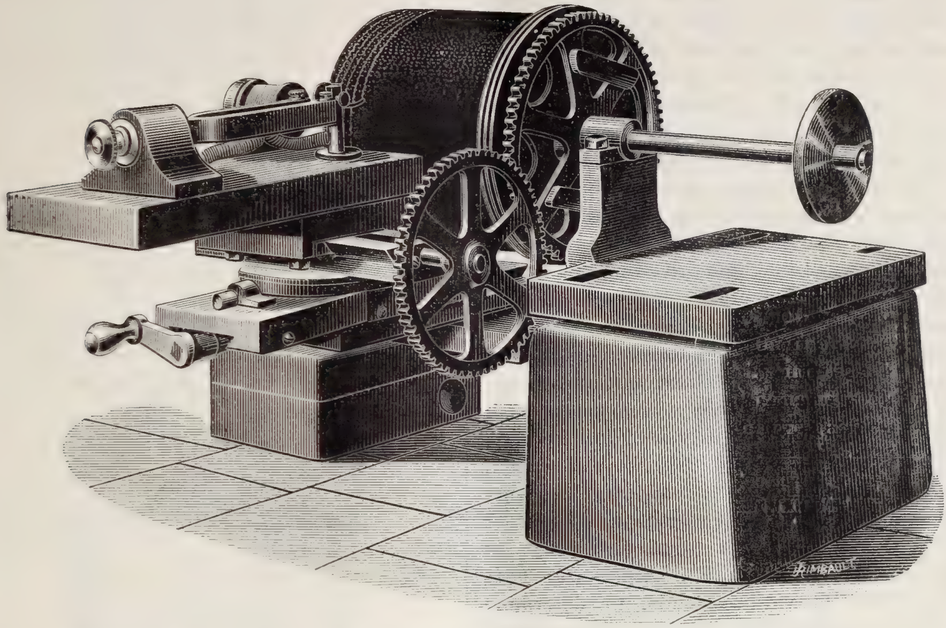
Fig. 19 shows the indicator diagrams for trials A_1, A_2, and B, expanded in the usual way. The diagrams in dotted lines are so drawn that their horizontal breadths at any pressure show the amount of *steam* of that pressure present in the cylinder, while the corresponding ordinate of the saturation curve shows the volume as steam of the same pressure of the whole feed-water per stroke.

SPEED TRIALS.

Attempts were made to obtain accurate records of the speed of the engines at every part of their stroke. Although these attempts were not so far successful as to justify a record of the results here, it may be well to describe the instrument used, as it has given perfectly consistent and satisfactory results elsewhere. This instrument was designed by Mr. H. B. Ransom in the engineering laboratory at University College. It consists of a drum covered by a prepared and blackened (smoked) paper, which drum revolves with the shaft whose velocity is to be measured. Near to the drum a tuning-fork is kept in vibration by means of an electric current. This tuning-fork is carried on a slide rest, and

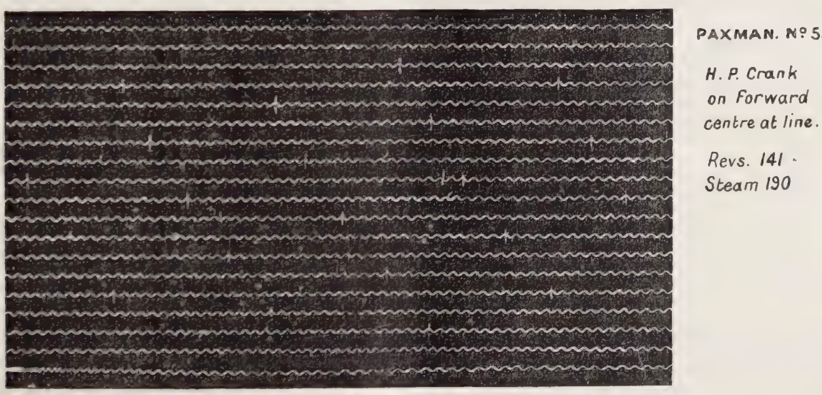
actuated by a screw in such wise as to travel parallel to the axis of the drum. One limb of the tuning-fork carries a light style of sheet brass, which rests in light contact with the drum. As the drum revolves and the tuning-fork vibrates, a wavy line is traced upon the paper. The number of waves in any length is a measure of the time taken by the drum in turning through a corresponding angle. The instrument is shown in Fig. 20.

FIG. 20.



Several diagrams were taken by this instrument from each engine, but when they were plotted out it was discovered that each was more or less affected by one or other of two causes of error. Owing to the direction in which the engines ran, and the position occupied by the slide rest, the drum had run towards the tuning-fork, and thus although the style of the tuning-fork was bent round, any tendency of the style to bite upon the paper was exag-

FIG. 21.



gerated, as the style was drawn down, hence the style was thrown in vibration in a plane perpendicular to the axis of rotation of the drum, which gives rise to an appearance of variation of speed where none existed. Again, it was necessary to extemporise some form of coupling between the axis of the drum and the shaft whose speed was to be measured. On plotting some of the curves, it became apparent that this coupling had not been effective,

and that the driving was in fact by a series of blows, the drum running ahead of the shaft between the successive blows. Both these defects can be remedied whenever the instrument is used again; they would have been remedied in these experiments had their full effect been discovered before the experiments terminated. The instrument has been used with perfect success both upon steam and gas-engines in the laboratory. Fig. 21 is a *fac-simile* of its indications, and Fig. 21 shows the working out of a diagram taken from an Otto engine at University College.

The effective observations made on the engines to determine the efficiency of the governing were as follows:—A lamp supplied from a dynamo machine driven by the engine was observed; the machine also supplied a resistance which could be suddenly varied from that which would take up the full power of the engine to about half-power, and to open circuit. These observations were made, firstly, with a steady load to determine the effect for cyclical variation of speed, and secondly, when the load was suddenly thrown off, to determine whether the governor hunted. Observations were also made of the speeds at which the engine ran continuously with various loads, to determine the sensibility of the governor, the governor remaining untouched between the experiments.

Atkinson.—A very slight variation in the brightness of the lamp could be detected when the engine was run with a steady load. So small, however, was it that it could only be detected by close attention, and it could not cause any annoyance; when the load was thrown off there was no sign of hunting.

The speeds taken by the counter for one minute in each case were as follows:—

Revolutions per minute.		Load.
128·5	......	Full.
128·5	......	Full.
130	......	One-third.
130	......	One-third.
130·5	......	Light.
130·75	......	Light.

The difference between maximum and minimum speeds is thus only 1·75 per cent. of the latter.

One feature about the working of this engine is particularly worthy of commendation, namely, its comparatively very quiet exhaust, which is due to the low pressure reached at the end of the expansion.

FIG. 22.

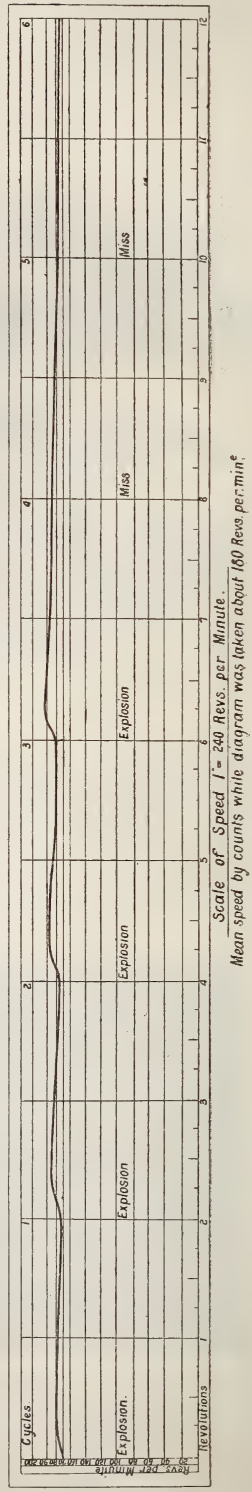


DIAGRAM SHOWING CYCLICAL VARIATIONS IN OTTO ENGINE AT U.C.L.

Crossley.—The dynamo was in all cases driven from the counter-shaft. No variation could be detected in the brightness of the lamps when the engine was run with a steady load. When the load was thrown off there was no sign of hunting.

Observations of speed were made for successive periods of five minutes, and the means taken, with the following results:—

	Revolutions Per Minute.	Explosions Per Minute.
Light without counter-shaft....	164·9	10·5
Light, but driving counter-shaft	162·3	19·0
With dynamo fully loaded	152·3	70·5
Dynamo, part loaded	153·2	53·6
Dynamo magnets only	160·6	34·0

The difference between the maximum and minimum speeds is here 8·27 per cent. of the latter, or 6·57 per cent. if the running without the counter-shaft be neglected.

As the smooth running of the dynamo is secured by means of a counter-shaft with a heavy fly-wheel upon it, it was desirable to ascertain the amount of slip of the belt, and the power actually lost in driving the counter-shaft. With the dynamo fully loaded, the counter-shaft and crank-shaft were simultaneously timed; the counter-shaft had a speed of 1,090 revolutions per minute, whilst its speed, calculated from the speed of the crank-shaft, was 1,159, the slip being thus 5·96 per cent. The engine was carefully indicated, running perfectly light, and driving the counter-shaft but no further load, with the following results, which have been already referred to under trial D of this engine.

Set of Diagrams.	Explosions per minute.	Mean pressure.	Indicated H.P.	Mean Results. Explosions per minute.	Mean Results. Mean pressure.	Indicated H.P.	Remarks.
A	10·6	74·0	2·53				
B	10·4	74·8	2·51	10·5	74·1	2·50	Running light.
C	10·4	73·6	2·46				
D	19·2	72·4	4·48				
E	18·8	72·0	4·38	18·9	72·3	4·40	Driving countershaft.
F	18·8	72·4	4·38				

The counter-shaft thus causes a loss of 1·9 h.p., which would probably be slightly increased when the engine was fully loaded. This loss is considerably in excess of that to be inferred from the difference of actual and calculated speeds, which is what we should expect, for the slip occurs precisely at the time at which the tension on the belt is greatest.

As the efficiency tests were made without the counter-shaft, about 2 h.p. has to be deducted from the brake h.p. there shown, to give the effective power when the engine is used with a counter-shaft as a motor to give perfectly smooth running.

Griffin.—No variation could be detected in the brightness of the lamp when the engine was run with a steady load.

When the load was thrown off there was no sign of hunting

Observations were made with full load and no load, with the following mean results:—

Load.	Revolutions per minute.	Explosions.
No load	204	14·3
Full load............	199·6	118·0

The difference between the maximum and minimum speeds is here 2·2 per cent. of the latter. It has been already mentioned that in this case we were able to ascertain that the engine was practically free from all cyclic variations of speed.

Paxman.—No variation in the brightness of the lamp could be detected when the engine was run with a steady load.

When the load was thrown off, the engine at once increased its speed, and the lamp its brightness, the governor then acted and over-corrected the error so that the lamp became for a short time dim. The engine again in-

creased its speed and the lamp abnormally bright. After several oscillations the engine settled down to a steady speed. The governor thus hunted considerably.

The following are the results of observations made with varied loads :—

Loads.	Revolutions per minute.
No load	148·5
Driving dynamo light	140·8
Full load	140·2

APPENDIX I.—MR. WILSON'S REPORT ON GAS AND COAL ANALYSES.

Coal Gas.—During each trial three samples of the gas supply were taken, at the beginning, middle and end of the trial.

In each case the three samples were mixed together, and duplicate analyses made.

	Volumes of Dry Gas.		
	Crossley engine trial, Sept. 19, 1888.	Atkinson engine trial, Sept. 21, 1888.	Griffin engine trial, Sept. 27, 1888.
Oxygen .... } Carbonic acid }	0·51	0·52	0·36
Carbonic oxide	3·96	4·19	4·58
Olefines...........	3·77	4·07	4·04
Marsh gas	37·34	37·73	36·14
Hydrogen.........	50·44	48·56	50·94
Nitrogen	3·98	4·93	3·94
	100·00	100·00	100·00

Average composition of olefines :—1 vol. = 1·81 vols. C_2H_4.

Flue Gases. — Paxman steam-engine. In each trial six samples of flue gas were taken at nearly even intervals throughout the trial, and analyses of each sample made.

September 26th, 1888 (*Trial A_1*).

	Volumes Dry Gas.					
	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6*
Carbonic acid	8·42	10·07	9·29	9·73	12·41	7·01
Carbonic oxide	0·00	0·00	0·00	0·00	0·00	0·00
Oxygen	10·96	9·65	10·64	9·91	7·33	12·98
Nitrogen	80·62	80·28	80·07	80·36	80·26	80·01
	100·00	100·00	100.00	100·00	100·00	100·00

* This sample of gas was collected within one minute of the end of the trial, when the grate was very far from being in its normal condition. It has, therefore, not been reckoned in with the others in finding the average composition.

September 28th, 1888 (*Trial A_2*).

	Volumes Dry Gas.					
	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
Carbonic acid	11·64	11·40	11·28	13·82	9·34	13·66
Carbonic oxide	0·00	0·00	0·00	1·90	0·00	1·46
Oxygen	8·26	8·24	8·67	3·99	10·19	4·26
Nitrogen.........	80·10	80·36	80·05	80·29	80·47	80·62
	100·00	100·00	100·00	100·00	100·00	100·00

Coal.—The coal employed for the "Paxman" steam-engine trials was carefully sampled, and gave on analysis—

	Parts by weight.
Moisture	1·21
Carbon	84·54
Hydrogen....................	3·65
Nitrogen	0·84
Sulphur	0·81
Ash	4·48
Oxygen, &c. (by difference)....	4·47
	100·00

CHARLES J. WILSON.
University College, W.C.

Description of Fig. 23.

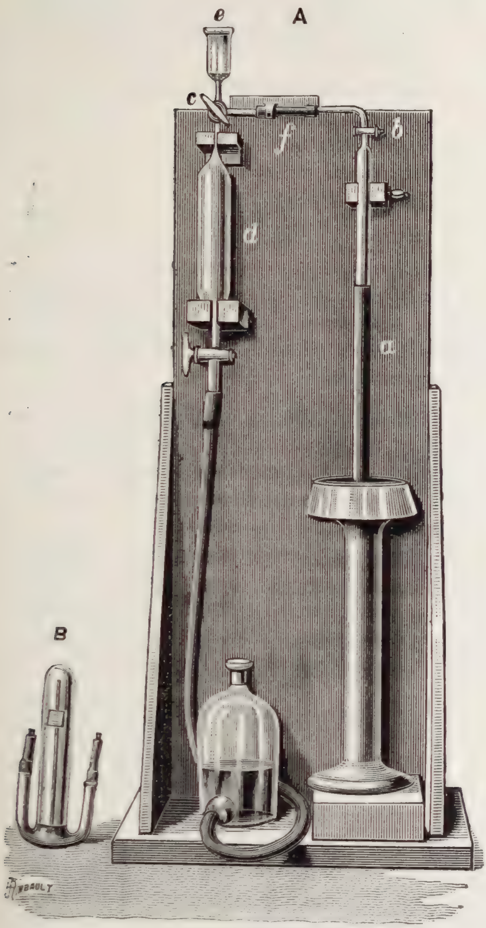
A. Apparatus employed for the gas analyses. The whole apparatus being filled with mercury, the gas is introduced into the eudiometer *a* and its volume measured. The stopcock *b* and the three-way cock *c* are then opened, and the gas passes over into the laboratory vessel *d*, followed by some mercury to drive all the gas out of the capillary tube. The reagent is then poured into the cup *e*, and admitted to the laboratory vessel by the three-way cock. When the absorption is complete, the mercury bottle is placed on the upper shelf and the cocks being opened the gas passes back into the eudiometer. When the reagent rises to *c* the three-way cock is turned to communicate with the cup so that the reagent passes into it. Some mercury is then driven over into the eudiometer to clear the gas from the capillary tube, and the volume is again read.

The two ends of the capillary tubes at *f* are made funnel shaped, and connected by a thick india-rubber tube. By lowering the eudiometer a little when the gas is passed from *a* to *d*, and raising it for the passage in the opposite direction, the whole of the gas is driven out of the tube by the current of mer-

cury; while the laboratory vessel can be readily disconnected for the purpose of cleaning it.

B. One of the tubes used for taking samples of gas. The sampler, completely filled with mercury, is connected with the gas to be taken by means of an india-rubber tube (previously aspirated if necessary). The vessel is then

FIG. 23.



APPARATUS FOR GAS ANALYSIS.

inclined so as to allow mercury to flow out of the opposite tube until only enough remains to seal up the sample. The rate of flow of the mercury can be regulated as required. The two side tubes are then filled up with mercury and caps put on.

APPENDIX II.—CONDITIONS OF TRIAL.

Four Gold Medals and Four Silver Medals are offered by the Council of the Society of Arts for Prime Motors suitable for electric-light installations.

The medals will be awarded on the results of practical tests, the conditions for which are as follows:—

1. The motors will be divided into two classes, *A* and *B*. Two gold and two silver medals will be allotted to each class.

(*A*.) MOTORS IN WHICH THE WORKING AGENT IS ALSO PRODUCED.

Steam.—Ordinary portable or semi-portable non-condensing engines.
Ordinary portable or semi-portable condensing engines.

Gas.—Coal gas or water gas with producer.
Hydro-carbon vapour.
Liquid hydro-carbon.

(*B*.) MOTORS TO WHICH THE WORKING AGENT MUST BE SUPPLIED.

Steam.—Detached engines, non-condensing, without boilers.
Detached engines, condensing, without boilers.

Gas.—Engines worked by illuminating or other gas.

Hydraulic.—Water motors.

Air.—Compressed-air motors.
Exhaustion motors.

2. Each class will be sub-divided into two groups—those declared to develop not more than 10 h.p., and those which will develop more than 10 h.p. and less than 20 h.p. Each motor will be worked at or about the power at which it is entered.

[The horse - power herein mentioned is equivalent to 33,000 lbs. raised one foot high in one minute, as measured on the brake.]

3. For four-horse power and under, the entrance fee will be £10; above four-horse power, the entrance fee will be £2 10s. per h.p. The fees to be paid on entry.

4. No competition will be held unless ten motors at least are entered.

5. In case of no competition being held, the entrance fee will be returned.

6. The Council reserve the right of refusing any entry.

7. All engines and boilers must be fitted up

in accordance with the Regulations of the Royal Agricultural Society.

a. All motors or producers subjected to more than a nominal pressure must be fitted with a pressure gauge. Before any motor can be worked, the pressure gauge must be verified by the judges.

b. There is no restriction as to the construction of motors, boilers, or producers, but the judges must be satisfied that the bursting strength of them is at least four times the working pressure, and that a hydraulic test of one and a half times the working pressure has been satisfactorily applied, if considered desirable.

c. Each exhibitor must declare the greatest pressure at which he proposes to work his motor.

d. No old boilers, that is boilers that have manifestly been at work for a considerable time, will be admitted without special thorough examination, and a certificate of safety from the judges.

e. Each boiler, of whatever form or size, must be provided with the following mountings :—

Two Safety Valves, each of sufficient size to let off all the steam the boiler can generate, without allowing the pressure to rise 10 per cent. above the pressure to which the valve is set.

Two Sets of Gauges for ascertaining the water level.

One Steam Pressure Gauge, which must be tested and verified by the judges before the boiler can be used.

A Half-inch Cock, terminating in a half-inch male gas thread, for the purpose receiving a testing pump.

One Check Feed Valve, immediately attached to the boiler, in addition to the ordinary pump valves, whenever the feed is introduced below the lowest safe water-level, or where there is a length of feed pipe between the engine and boiler.

f. The judges reserve to themselves the power of affixing any gauges that the peculiar nature of the machinery may call for, with the object of ensuring safety, and of obtaining information.

g. Exhibitors must be provided with all the appliances necessary for taking the working parts of the machinery to pieces, for examination, should the judges require it.

h. Shafting, belts, gearing, high - speed machinery, and any other exhibits likely to prove dangerous, shall be securely fenced and protected to the satisfaction of the judges, but such approval shall not relieve the exhibitor from his own liability.

8. The points of merit considered of the greatest importance are—

a. Regularity of speed under varying loads.

b. Regularity of speed during the various parts of one revolution, or one cycle of revolutions.

c. Power of automatically varying speed to suit arc lights.

d. Noiselessness.

e. First cost.

f. Cost of running.

g. Cost of maintenance.

[In estimating the comparative value to be allotted to each of these points of merit, the judges will give due consideration to the characteristics of each kind of motor, steam, gas, water, &c.]

9. The tests will be carried out under the direction of three judges appointed by the Council of the Society of Arts, who will report to the Council, and will confer with them on the awards.

10. The Council will publish the awards in the *Journal of the Society of Arts.* They reserve the right of publishing descriptions of any of the motors, and the competitors must afford every facility for this purpose.

11. The competitors must take upon themselves, in exoneration of the Society, all claims in respect of damage (if any) resulting from the testings, and must renounce all claims for compensation for any injuries, real or imaginary, that they may incur from alleged or actual imperfection in the arrangements, or in the testings, or from any statement in the report or description published.

12. The competition will take place in London about May or June, 1888. Entries must be sent in by the 21st December, 1887.

13. All costs of fitting up and working the motors must be borne by the exhibitor. The Society will provide the brakes, indicators and apparatus, electrical and other, necessary for making the tests.

14. The Council reserve the right of withholding any or all the medals.

TENTH ORDINARY MEETING.

Wednesday, February 13, 1889; JAMES SHOOLBRED in the chair.

The following candidates were proposed for election as members of the Society :—

Dewick, Rev. Edward Samuel, M.A., 26, Oxford-square, Hyde-park, W.
Gutteridge, Richard Sandon, M.D., 58, Brook-street, Grosvenor-square, W.
Howell, John Charles, 23, De Vere-gardens, Kensington, W.

The following candidates were balloted for and duly elected members of the Society :—

Oman, J. Campbell, 2, Parnell-terrace, New Southgate, N.
Riches, James, 6, Great Winchester-street, E.C.
Serre, Charles A., Cordova-road, Grove-road, Mile-end, E.
Shirley, John Rogers, Ridley-park, Delaware County, Pennsylvania, U.S.A.

The paper read was—

SALT; ITS PRODUCTION AND CONSUMPTION AT HOME AND ABROAD.

By P. L. SIMMONDS, F.L.S., F.R.C.I.

Notwithstanding that salt is an article of daily use as a condiment in every household, there are comparatively few perhaps who know how or where it is obtained, or are acquainted with the chemistry of this most interesting and important substance. Salt is one of the chemical agents provided for the use of man, which is manifestly indispensable to his existence and happiness. It is furnished in the most bounteous manner, and the procuring and manufacture of the substance forms one of the great branches of industry in this and other countries.

We find the same word employed to designate salt in most of the languages of the world. There is hardly a dialect that does not abound, too, in praises relating to salt. To eat salt with a man, among the Arabs, is a pledge of friendship. The Bible has many references to it, as, "with all thine offerings thou shalt offer salt," and one of these has no doubt puzzled many a reader. It is found in the Sermon on the Mount, "Salt is good; but if the salt have lost his savour wherewith shall it be salted?" This is explained by the fact that the salt used in Palestine is very impure, containing large quantities of magnesium chloride, and that if kept in a damp place it becomes very bitter, and "is neither fit for the land, nor yet for the dung-hill."

Salt is remarkable as constituting the only mineral voluntarily eaten by man, although others are administered medicinally. Not only does it afford an indispensable and wholesome condiment for our tables, but it forms an essential constituent of the blood, and supplies to the human system the loss sustained by saline secretions. According to Professor Church, "its chlorine helps to furnish the hydrochloric acid of the gastric juice, and the chlorine of the chloride of potassium found in red blood-corpuscles, and in muscle. Its sodium forms part of the soda-salts which are the characteristic constituents of the bile, and of the phosphate of soda of the blood." When moderately used, salt acts as a gentle stimulant to the stomach, and gives a piquancy and relish to our food.

The use of salt is universal with all nations, civilised or savage, and when one barbarous tribe trades with another, the first article of barter is generally salt. It is immensely valuable with those people who live remote from the natural sources of supply.

To the native of Africa, India, and China, it is a necessary seasoning of his insipid vegetable food. The little negro in many districts of Africa enjoys a lump of salt as much as our boys do a sugar-stick, and there are, doubtless, those who can remember the time when salt, being 6d. a pound in this country, was much more prized, and prudently used in households, than it is at present.

Salt may seem a very insignificant product, owing to its cheapness with us, but its collection and preparation is nevertheless a most important manufacture, involving in Great Britain alone a capital of several millions sterling. The salt production of the world it would be difficult to estimate, because it is not only always industrially produced, but in many localities, especially in hot countries, it is natural and spontaneous. The United Kingdom produces 2,200,000 tons, the other countries of Europe about 3,000,000, North America rather over 1,000,000, Asia and Africa about another 1,000,000, making a total of 7,200,000 tons.

Few have any idea of the enormous consumption of salt in the arts and manufactures. It is the source of all the chlorine that is so extensively employed in bleaching, and in the chemical manufactures considerable quantities are also used for the preparation of hydrochloric acid, sal ammoniac, and many other

products. It is estimated that nearly 750,000 tons are consumed annually by British metallurgists and chemical manufacturers.

Salt forms indirectly a material for the making of soap and glass. Besides, it is used in tanning, for glazing pottery, for the extraction of silver and copper from their ores, for the preparation of mixtures for producing cold, and for many other purposes. The extent and importance of the uses of salt can scarcely be better described than in the words of Dr. Bolley, which we translate from his work, entitled "Das Kochsalz:"—

"We awake in the morning; the linen which we put on betrays by its whiteness that it has been bleached by the chlorine derived from salt; the shoe with which we cover our feet required salt in the hands of the tanner; in the soap that we use for the toilet, we seize a transformed piece of salt; the glass, which we bring to the mouth, hides the chief ingredient of salt; from the crude ore by means of salt was produced the bright, white metal of the tea-spoon, which is so highly esteemed by the world; the tea-kettle is soldered with borax which holds soda produced from salt; the milk before us contains salt; the butter has been preserved by it perhaps for months; the bread betrays to the palate that the dough has been mixed with salt. We grasp the paper; it required the application of chlorine from salt in order to please us by its whiteness. The clean spectacles through which we see are partly composed of what once was salt. A visit is announced; a patient wishes to consult us; he enters, and seeking scientific aid, we reflect upon the remedies at our command and commence to write. Out of ten medicines we find that five of them owe their origin, either by their composition or the mode of their preparation, to salt. Who is able to forget for one moment this ever present Proteus that appears in a thousand forms?"

Salt is much used, too, in agriculture, as an addition to soils, which it keeps moist in the heat of summer, and soft during the frosts of winter. If used freely, it destroys most weeds and vermin.

If any further evidence were required as to the utility of salt, it would be found in the powerful instinct which impels animals to obtain salt. Buffaloes will travel for miles to reach a "salt-lick," and the value of salt in improving the nutrition and the aspect of horses and cattle is known to every farmer.

The public were startled last year by the formation of a powerful Salt Union, which bought up the properties of many of the producers. The reason for this was that an insane competition had brought the market price of salt to such a point that, while it cost 4s. 6d. to produce a ton of salt, its sale price had been forced down to 2s. 3d. The salt manufacturers were actually losing 100 per cent. on their business, though the price of salt for domestic use was kept up to £4 13s. 4d. per ton, or about ½d. per pound; the middleman securing all the enormous difference in price. No doubt the result of the combination will be that salt, for purposes of industrial manufactures, will rise to a price which will return a fair profit; but it will never reach a higher price than that at which several neighbouring European countries can export it. This combination of salt proprietors is no new matter, for the action was proposed some sixteen years ago, but not then carried out.

It was stated recently in an article in the *Times* that, "The total quantity of salt raised in Great Britain in 1887 was 2,193,951 tons. Of that quantity 818,713 tons were exported, leaving about 1,375,000 tons for consumption in the United Kingdom. If we take the population at 37,000,000, and the average domestic consumption, for all purposes, at 40 lb. per head, it would follow that the domestic consumption would absorb only 660,000 tons of the total national consumption, leaving a balance of some 715,000 tons to be used in the many chemical and other industries into which salt enters as a raw material. To increase the present price of salt by 5s. per ton would therefore be equivalent to raising for the salt-owners a sum of about £200,000 per annum, at the expense of the other industries of the country. Whether the chemical trade, which is the one chiefly concerned, can support such a burden without being prejudicially affected is a question which time alone can determine. It is important to remember that the chemical industry has for years past been in anything but a flourishing condition. Some Continental countries, and especially Germany, have been running our chemical manufacturers very hard in neutral markets. Those countries have, at the same time, been largely and rapidly developing their own resources in salt."

We have no means of accurately ascertaining the quantity taken for home consumption, but the Customs returns still provide correct data as to the amount of salt exported.

The following shows the exports at decennial periods:—

	Tons.	Value £.
1840	321,192	213,479
1850	395,492	224,501

	Tons.	Value £.
1860	696,725	358,162
1870	764,707	381,888
1880	1,051,240	673,523
1888	899,270	486,651

The average export of the last four years has been 861,164 tons, but the aggregate value now is nearly £186,000 less than it was four years ago.

The consumption of salt per head in different countries may be roughly stated to be as follows:—

	lbs.
United States	50
England	40
France	30
Italy	20
Russia	18
Belgium..............	16½
Austria	16
Prussia	14
Madras	13
Bengal	13
Spain	12
India—Bombay	10¼
Switzerland	8½

In 1855, the salt raised in this kingdom was 1,118,991 tons; since then it has doubled, but the price has gone down very much. In 1855 it was 25s. a ton; in 1875, when 2,316,644 tons were raised, the price was but 13s. per ton. Now it has fallen to less than half this sum.

There is no country better supplied than England with brine springs and beds of rock salt. In the early part of last century, English salt was supposed to be inferior to that of several countries, and, in consequence, considerable quantities of foreign salt were imported, while very little native was exported. The manufacture, however, progressively improved, and the production of the article, both for home and foreign consumption, has become a branch of national industry, inferior to few in extent and value, as regards tonnage and traffic, and susceptible of almost indefinite extension in proportion as new markets are opened up, and remunerative prices obtained.

In Cheshire, natural brine is found at a depth of 120 feet to 150 feet from the surface, or is obtained by flooding old rock-salt mines. There the rain water easily finds its way to the salt, which it readily dissolves, and the brine runs for miles on the surface of the rock salt, or "salt-head" as it is called, and it is only necessary to sink a shaft this short distance to obtain the natural brine. On the Tees the conditions are altogether different in two essential points. There is no natural brine, and the rock salt is about ten times the depth. The rocks immediately overlying the salt are impervious to the water contained in such quantities in the sandstone above the marls, and from which the brine is artificially produced.

The quantity of saline matter contained in the springs at Droitwich is about 45 parts in 100. The supply of this valuable fluid seems inexhaustible; its strength and quality have been for centuries the same. With the present works it is estimated that 260,000 tons of salt are annually manufactured from the Droitwich brine.

In a paper by Mr. T. W. Stuart, read before the Society of Chemical Industry in October last, some interesting details were given on the rapid development of the salt industry on the Tees, which has been such an important boon to the alkali manufacturers of that district. The bed of rock salt discovered at Middlesborough has been found to exist over an area rather more than four miles long by two and three-quarters broad, or about twelve square miles, and allowing for its known unequal thickness, each square mile is estimated to contain 100,000,000 tons of salt.

The consumption of common salt on the Tyne in 1887 was 116,486 tons, and the local production 136,000 tons, so that this is in excess of the consumption by the alkali manufacturers in the district.

Mr. Stuart states that "the fineness or otherwise of the grain in the different varieties of salt depends simply upon the temperature at which the brine is kept during evaporation. The higher the temperature the finer the grain, and the lower the temperature the larger is the crystal. The different kinds of salt are divided into boiled and unboiled. The fine grained salts, such as butter, cheese, block, and domestic salts, are made in short pans of about 35 feet long, and kept at 224° Fahr., the boiling point of saturated brine, the pans being drawn twice daily. Block salt is made by filling this salt into wooden moulds, and drying in stoves by the waste heat from the pans, while superfine salt is produced by grinding these boiled salts. Unboiled salts, such as common and fishery, are produced at temperatures below the boiling point of brine. For common salt the brine is kept at about 160° to 190° Fahr., and the pans drawn every two days, whereas for the larger grained or fishery salt the brine is

evaporated at about 130° to 160° Fahr., and the pans drawn every four or five days, extra fishery working at 100° to 110° Fahr. Large-grained bay salt is worked at 75° to 80° Fahr., and drawn every three or four days."*

Heavy excise duties were for a long time imposed upon salt; they were first levied in the reign of William III. In 1790 the salt duty amounted to 5s. a bushel, subsequently increased in 1805 to 10s., and in 1806 to 15s. a bushel, and then lowered to 2s. The average annual home consumption until the duty was removed in 1825, was, according to the Excise, about 2,000,000 bushels, or 50,000 tons. Perhaps no tax was ever more unpopular than the salt tax. In addition to the quantity that paid duty for home consumption, a large amount was supplied duty free for exportation, for the fisheries, for Ireland, and for bleaching; and it was principally from this source that smugglers obtained the salt for carrying on an extensive contraband trade.

Rock salt is almost exclusively exported, a very small portion being retained for home use. In the time of the duty it was only charged on export with a penny a bushel. The total quantity of salt, white and rock, accounted for by the Excise tables, entered for home consumption, and exported in the year 1821, just previous to the remission of the duty, amounted to 12,526,297 bushels, which at 56 lbs. a bushel, was equivalent to about 313,159 tons. In many countries much salt is made by evaporating sea water.

The composition of sea water varies with the latitude and locality. The sodium chloride increases in the equatorial seas, and diminishes in the polar seas. It is a singular fact that when sea water is frozen, the ice formed is perfectly free from salt, water rejecting the saline ingredients in the act of crystallising. The solution becomes more and more concentrated, and, consequently, it requires a greater degree of cold to form the ice.

The quantity of salt, or muriate of soda, varies in different seas, but the mean is about $2\frac{3}{4}$ per cent. Under the line, or at the equator, the water will be found to contain 1-7th salt, near Iceland 1-12th, about the Norwegian coasts 1-10th, near the Spanish coasts 1-48th part.

In Sweden, Russia, and other northern countries, salt is sometimes obtained by freezing the sea water in large reservoirs. The ice thus formed consists of pure water; the mother liquor, therefore, by repeated congelation becomes more and more impregnated with salt, and can be profitably boiled down. The salt thus obtained is, however, far from pure.

* "Journal of Society of Chemical Industry," vol. vii.

Having dealt generally with salt, and its production and consumption in this kingdom, I shall now pass on to notice its production and commerce in Europe, America, and other parts of the world.

Europe.

France.—The consumption of salt in France might be made the history of the "Gabelle" which sent thousands of peasants to the galleys. From 1830 to 1849 the annual consumption per head was only 10 or 12 lbs.; upon the reduction of the duty, the quantity consumed rose to 18 lbs. In 1846, with an average consumption of 12 lbs., the amount of duty was nearly £2,750,000 sterling, or about two francs per head.

In 1885, the tax on salt brought into the Customs £850,240, and the indirect tax, or that out of the range of the Customs, £485,240, together £1,335,480. This was besides that levied on imported salt.

Table salt is furnished in France by the mines in the departments of Meurthe et Moselle and Doubs, and by the salt works carried on in the Bouches-du-Rhone and on the borders of the ocean, principally at the Lake of Ré, the Landes, Charente-Inferieure and Loire-Inferieure. The production of the salines is very variable, hence a fluctuation in price. On the average 100 kilos (2 cwt.) cost $2\frac{1}{2}$ frs., to which has to be added $12\frac{1}{2}$ frs. for tax, bringing up the price to 15 frs. for table salt.

According to official statistics of the duty, the consumption of salt in France in 1876 was 301,328,000 kilos, valued at 45,199,200 frs. The export was 1,862,000 kilos, of the value of 3,019,000 frs., making a total of the value of 48,218,000 frs., or nearly £2,000,000 sterling.

Agriculture and manufactures used up 150,000,000 kilos, free of duty, so that the production then was about 545,000 tons.

The production of salt in France is now estimated to be over 650,000 tons, obtained as follows:—

	Tons.
Salines of Midi	300,000
,, of the West	250,000
,, of the East and the Pyrenees	100,000

The consumption absorbs about 547,000 tons, of which 370,000 are for food, 50,000 for chemical industries, 60,000 for the fisheries, 60,000 for export, and 7,000 for salting fish

under the superintendence of the Customs, so that the production exceeds the requirements and demand by about 103,000 tons.

The Mediterranean salt is in large white crystals, relatively pure. That obtained from the salines on the Atlantic coast is what is termed grey salt, coloured by the earth of the salt-pans, and it has to be washed or refined to remove the foreign substances.

The imports of salt at Marseilles have increased of late years from 29,000 tons in 1870 and 1871 to 71,000 tons in 1886. Of this quantity 25,000 tons were taken for chemical manufactures, 50,000 tons being used in the soap works there, and 41,000 tons were exported to the fisheries.

Italy, besides supplying its local wants, exports about 250,000 tons of salt. The places of production number in all about eleven. Almost all are Government property; a few are let to private industry, and five others are managed directly by the State. It is estimated that the Government realises a profit from this article of £2,500,000 to £3,000,000. The Government exercises a monopoly in the continental provinces only.

Salt is generally obtained by natural evaporation of sea water, but in several salines, such as Volterra and Salso-Maggiore, artificial evaporation is employed. The production reaches over 400,000 tons a year. The Sardinian salt works are situated at Cagliari and Carloforte. They produce about 146,000 tons, and employ nearly 800 persons, collecting the salt between July and October.

A good account of the salt manufacture in Italy will be found in vol. xxix. of the Society's *Journal*, p. 609, for 1881.

PRODUCTION OF SALT IN ITALY, 1882.

	Tons.
By the State	78,013
Cagliari, Carloforte, San Felice, and Veneto	146,798
Private Salines:—Trapani, Paceco, Marsala, Argusta, Pachino, and Syracuse	177,000
	401,811
Rock salt	18,800

The average production of salt in other districts may be given as follows:—

	Cwt.
By the State—	
Cervia	80,000
Comacchio	150,000
Corneto Tarquinia	60,000
Lungro	60,000
Margherita, Savoy	350,000
Porto Ferraio	20,000
	720,000
By private firms—	
Cagliari	1,500,000
Salso-Maggiore	3,000
San Felice	100,000
Volterra	80,000
	2,403,000

Portugal.—The sea salt works of Portugal are very extensive, and produce about 250,000 tons annually. The centres of the manufacture are Setabel, Lisbon, Aveiro, and Algarve. The salt of Setabel is of great repute in continental commerce. Owing to the favourable climate, it is obtained in enormous quantities, at a very low price. About 100,000 tons are exported there yearly, and Spain ships about 250,000 tons in all.

Passing to the northern States of Europe, Denmark imports about 25,000 tons of salt annually. Sweden, salt to the value of £83,000. Norway imports 68,750 tons. In 1876, Russia imported 311,000 tons of table salt; this dropped to 180,000 tons up to 1883, and has since fallen to 25,000 tons in 1886. At Karna, in the district of Solikainsk, about 36,000 tons of salt are obtained.

In Germany, in 1870, 2,000,000 tons of rock salt were raised by 2,432 establishments, employing nearly 200,000 workpeople. At present the German Empire produces about 800,000 tons of table salt, from which a revenue of over £1,000,000 sterling is derived.

The following figures were given recently in the *Times*:—

"Within the last ten years the production of rock salt in Germany has considerably more than doubled. France has also considerable resources of the same kind, and for the last few years has produced, on an average, upwards of 700,000 tons of salt per annum. If we take the official value as well as the quantities of the salt produced in the different leading countries in the latest year for which the returns are available, we find the following results:—

	Production. Tons.	Value.	Average per ton.
Germany	444,400	£107,550	4s. 8d.
France	739,823	630,000	17s. od.
Italy	17,204	12,300	14s. 3d.
United States......	880,000	986,500	22s. 4d.
United Kingdom	2,193,951	732,320	6s. 7d.

It would appear from these figures that Great Britain has little to fear from the competition in neutral markets of any other salt-producing country except Germany, where the average official value of the salt produced is nearly 2s. per ton less than in our own country. In spite, however, of this difference, we export to Germany considerable quantities of salt every year, which is a tolerably sure proof that if Germany has the right sort of salt, she has not yet developed it to a really competitive point."

Austria.—The production of salt in the Austrian empire is a monopoly of the State.

Rock salt is found in inexhaustible seams in the Carpathians, especially at Wielczka and Bochnia, in Western Galicia, and in Hungarian Marmaros, and Transylvania. The Alps containing the principal saline veins, are Hallstadt, Ischl, Hallein, Anssee, and Hall. The production of the monarchy in 1876 was 3,542,491 metrical quintals of 2 cwt., of which 345,000 were marine salt, and 154,000 supplied for industrial purposes.

Salt is obtained in *Turkey* by evaporation of sea water at the south of Arvalik, at Fokia, and in the Gulf of Smyrna. It brings in a revenue to the State of about £250,000. The annual production in the province of Smyrna is 75,000 to 85,000 tons.

Solar salt, or that evaporated from sea water, is produced in impermeable shallow basins called salines or salt marshes. The soil chosen for them should be in general argilaceous and not porous.

The Society of Salines at Venice is a considerable establishment, where is applied with success the process of M. Balard for heating sea-water. At Marmaros, Hungary, there is an important manufacture of salt from the salines by the Imperial Finance Administration. The Society of Salines at Pirano, Istria, also carry on an important production of sea-salt. There are several salt fields on the coast of Greece; one produces white salt, another so-called black salt, which is of a slightly grey colour. The salt pits are situated at Corfu, Santa Maria, and Leftuno. In the Crimean peninsula the salt lakes produce about 200,000 tons annually.

In certain countries mines of salt, crystallised like precious stones, are met with, and it is termed rock salt. The most important are those of Saxony, the Salzkammer in Austria, Wielczka in Galicia, and Bochnia in Poland, Strassfurth in Prussia, and Cordova in Spain. They are found also in Southern Germany, in Bavaria, Wurtemberg, and some localities in the south of France. The Wurtemburg salt deposits yield £20,000 a year to the State.

There are extensive salt mines in Cracow, Poland, which furnish about 225,000 tons annually.

America.

Crossing the Atlantic to North America, we obtain the following details as to the salt production in the Dominion of Canada and the United States.

The total consumption of salt in Canada, for all purposes, seems to be about 158,500 tons. Nearly all that produced in the Dominion is manufactured in Ontario, adjacent to Lake Huron. There are about nineteen wells working, the largest number being situated in the county of Huron, six are located at Goderich, where the salt was originally discovered.

The process of manufacture resorted to consists of pumping the brine from the wells, and evaporating, by artificial heat, in large pans made of boiler plate. From these the salt is raked, from time to time, as it crystallises out from the solution, the pans being only emptied at intervals for cleaning.

The province of Ontario is possessed of the most extensive deposit of rock salt which has yet been proved on the American continent. The salt was first discovered at Goderich, about twenty years ago, at a depth of 1,010 feet, by a boring which was made for petroleum. The first bed was 31 feet thick; the second, at a depth of 1,085 feet, was 25 feet; the third, at 1,127 feet, was 35 feet thick; the fourth, at 1,223 feet, 16 feet; the fifth bed, at 1,243 feet, 13 feet; and the sixth, at 1,385 feet, 6 feet. There is thus here a thickness of 126 feet of solid rock salt. This is equal to 365 tons per square acre, or the enormous quantity of 223,600,000 tons of salt underlying each square mile. The second and third beds are very pure salt, fit for mining and sending to market, after being crushed to the necessary fineness.

The salt measures of Ontario extend over an area of 1,200 square miles, and the diamond drill has established, as I have stated, the thickness of solid rock salt at 126 feet, lying between 1,000 feet and 1,400 feet below the surface, upon the shores of Lake Huron, at the harbour of Goderich. This salt rock is of exceptional purity; one stratum over ten feet thick is reported to contain by analysis $99\frac{3}{4}$ per cent. of salt. It is worked by boring, dissolving the rock by the surface water, which

descends the bore-hole, pumping up and evaporating in pans the strong brine so obtained. This salt was formerly shipped in bulk to Chicago, Cincinnati, and St. Louis, but the heavy American duties now levied have stopped this trade. The principal wells are those at Goderich, Clinton, Seaforth, and Kincardine. The area is extensive, extending a distance of over forty miles long by seven or eight miles wide.

There were in 1887 seventeen producers of salt in Ontario, and one in New Brunswick, and they employed about 273 men. Compared with the preceding year the marketed production shows a decrease in 1887 of 2,186 tons, but an increase in the value of 6,012 dollars for the salt alone (exclusive of packages).

The imports of coarse salt paying duty were, in 1886, 865,936 lbs.; in 1887, 764,774 lbs.; of fine salt paying duty, 1886, 10,747,628 lbs.; 1887, 9,088,980 lbs.; and of salt duty free for the fisheries, in 1886, 208,534,332 lbs.; in 1887, 186,846,668 lbs.

In general, four grades of salt are made:—

1. Any dirty salt, got in cleaning the pans or otherwise, is put on one side and sold to the farmers for land dressing.

2. Clean but coarsely-crystallised salt, produced by the slower evaporation which takes place at the end of the pan furthest from the fire. This is sold for packing pork or fish, or ground to make dairy salt.

3. Fine salt, which constitutes the great bulk of the product, and is of much finer grain than the last, being crystallised much smaller from being evaporated more quickly.

4. Dairy salt is produced either by grinding the coarser salt, or it is crystallised very small by rapid evaporation.

In the North-West Territory all the salt used on the Peace and Mackenzie rivers is obtained at Salt River, a considerable stream emptying into Slave River 100 miles below Fort Chippewyan. Some distance up this river a number of brine springs are scattered over a wide plain, and around these large accumulations of excellent salt are deposited. Professor Macoun says, "Men who have been there told me that the salt is of unknown depth and extent, and it is supposed that there are vast deposits at an inconsiderable depth below the surface."

There was formerly a salt association in Canada, which was dissolved four years ago, and a great fall in price ensued.

The salt industry in Canada, as in England, is at present much depressed, the prices obtained being so low as to leave a very narrow margin of profit.

In 1873, the average price of the barrel of salt (280 lbs.) was nearly a dollar; now it is not half that, fetching only 38 cents nett, and the cost for fuel, wages, commission, &c., amounts to close on this figure.

The Canadian manufacturers have to contend also with the expense of transport to the coast for use in the fisheries, and the further disadvantage of English salt being brought over free as ballast, or at a merely nominal charge.

In 1872, the production of salt in Canada was 50,589 tons, the average value being 5¾ dollars per ton. In 1873, 66,261 tons were produced, and the value was a dollar more per ton. In 1881, 247 hands were employed at the salt works. The sales of salt in the Huron district in recent years have been as follows:—

	Tons.
Year ending March, 1883 ..	44,133
,, ,, 1884 ..	39,296
,, ,, 1885 ..	33,782
,, December, 1886	62,359
,, ,, 1887	60,173

The total value of the salt in the last-named year at the works was £33,284, an average price of 2¾ dollars per ton. The value of the salt imported into Canada in 1887 was 286,676 dollars, and of that exported 11,526 dollars. There is a duty in Canada on salt imported in bulk of 10 cents per 100 lbs., and of 15 cents when in bags, barrels, &c.

Newfoundland requires a good deal of salt for its codfish, the imports averaging about 50,000 tons annually, but we only ship there 3,500 tons.

Our exports of salt to Canada and Newfoundland have been as follows:—

	To Canada. Tons.	To Newfoundland. Tons.
1883	98,073	4,495
1884	70,181	6,156
1885	77,964	2,695
1886	66,342	1,962
1887	72,921	2,367
	385,481	17,675
Average..	77,096	3,535

Last year the shipments to British North America were 78,184 tons.

Forty years ago, we used to send to the United States and the British American Provinces over 5,000,000 bushels of salt (125,000 tons). Russia, Prussia, Holland, Belgium,

and other Continental States also took then about as much. Our shipments to America have nearly doubled since then, but the exports to Europe have not increased so largely. The quantity shipped in 1887 was 248,000 tons to the United States and British America, and 145,752 tons to the European States. Last year the shipments were much smaller, viz., to North America 227,336 tons, and to European States 111,699 tons.

United States.—Most of the salt wells in the United States are artesian borings, which furnish a constant flow of brine. The most extensive works of this kind are at Syracuse, New York. The salt brine is received in tanks similar to those used upon the sea shore, but the final concentration is accomplished in iron pans heated by furnaces. The salt deposits in the United States extend over the whole region between the Alleghanies and the Mississippi, but are in no case, if we except the bed at Petit Anse, Louisiana, of sufficient purity to admit of working directly upon the rock.

The amount of salt manufactured at Onondago, New York, about 30 years ago, was 7,000,000 bushels, nearly all made by boiling. There were also imported then about 15,000,000 or 16,000,000 bushels. The bushel contains 50 lbs.; about 40 bushels of salt go to the ton. There were 340 salt manufacturers in the States, 192 being in New York, 47 in Pennsylvania, 40 in Virginia, and 32 in Ohio.

The following details may be given respecting the manufacture of salt at the Kanawha salines in Virginia. The brine is procured from borings, 800 to 1,200 feet deep, and generally pumped out by steam, but in two or three wells it is forced up by the pressure of confined gas, in one case to a height of 200 feet above the surface. The gas alluded to is carburetted hydrogen, and its value is very great to the manufacturer since it is found to be sufficiently abundant to supply the place of fuel under the evaporators, saving, in many cases, all the coal which was formerly required. There were, a year or two ago, in operation 28 furnaces for evaporating the brine.

The chief local sources of supply for the large consumption of salt in California are the Alameda and Los Angelos salt works, and Canon Island on the coast of California. On the Alameda side of San Francisco Bay there are several companies located, whose works extend nearly twelve miles along the shore, and afford employment to over 150 men. The quantity of salt annually collected exceeds 10,000 tons, all prepared by solar evaporation. The salt water is retained in reservoirs during high tides, and evaporated in shallow ponds ranging in size from 20 to 500 acres.

The other principal manufactories of salt from sea water in the United States are along the shores of Cape Cod and at Nantucket. Most of the salt wells in America are artesian borings, which furnish a constant supply of brine. The most extensive works of this kind are at Syracuse, New York. West of the Rocky Mountains salt is very abundant, often forming incrustations on the surface of the ground. The water of Salt Lake, in Utah, is almost a saturated solution, and the spray from its surface envelopes everything with a crystalline covering. These incrustations cover acres of ground on the Pacific Coast, and look in the sun like vast fields of snow.

Taking the latest official returns available (1886), the consumption of salt in the United States appears to be as follows:—

	Tons.		Value in dols.
Production	953,385	....	4,736,586
Imports	390,168	....	1,438,031
	1,353,553	....	6,174,616
			£1,234,923

So that the average value of the salt would seem to be nearly £1 per ton.

In Chili, there is a salina or salt deposit in a lagoon called the Laguna Di Manicurga, from which huge blocks of salt are obtained, which are sold either to shops for domestic purposes, or to amalgamating establishments for use in the extraction of silver from the ore.

The length of the lagoon is said to be about six leagues, and its breadth two or three leagues. The water with which the mass of the deposit is saturated is so strongly charged with salt, that the whole surface of the lagoon, white as it is from the colour of the borate of lime, is made still whiter by a crust of salt from a quarter to half an inch thick, which covers the whole of it, and dazzles the eye by reflecting the light of the sun, which shines with great intensity in those upper regions. Many deposits of sulphate of soda in the anhydrous state are found in various parts of the desert of Alacama. One deposit cut in two by the railway between Caldera and Copiapo was examined by a German chemist, who stated that it was five and a half miles long by one-third of a mile wide, and that the sulphate

of soda existed to the extent of 50 lbs. to the square metre.

Asia.

Passing now to *Asia*, we find the principal sources of salt production in India are the salt range in the Punjab, the salt Lakes of Rajputana, a few other scattered salt lakes in various parts of the country (such as the Chilka Lake in Orissa), sea water, and the European imports of about 400,000 tons. Salt is sold from ½d. to 1d. a pound, according to the distance it has to be taken, on an average it retails at ¾d. a pound, of which two-thirds go to the Government as duty. The total consumption is now about 1,100,000 tons, of which 700,000 tons is obtained locally. The annual consumption per head in Bombay is 10¼ lbs., and in Sind 8 lbs. The duty charged is two rupees per maund (of 82 lbs.), which brings in a net revenue of over £6,000,000 sterling to the Government.

Salt Revenue, India, years ending March.

	Gross.		Gross.
1866	£5,342,149	1877	£6,305,869
1867	5,345,910	1878	6,469,455
1868	5,726,093	1879	6,948,973
1869	5,588,240	1880	7,246,014
1870	5,888,707	1881	7,092,515
1871	6,106,280	1882	7,355,022
1872	5,966,595	1883	6,161,360
1873	6,165,630	1884	6,124,704
1874	6,150,662	1885	6,480,794
1875	6,229,396	1886	6,325,742
1876	6,245,555	1887	6,624,888

There are four kinds of country salt met with in the bazaars of India:—

1. Rock salt, regarded by the natives as the best, mainly because it has not been boiled. It is obtained from the Cis-Indus and trans-Indus salt mines.

2. Sea salt, extensively manufactured in the Madras Presidency under a system of Government supervision, the revenue obtained being over a million and a half pounds sterling.

3. Lake salt, procured from the Ajmer salt lakes, the water naturally evaporating during the hot season.

4. Earth salt, which is common salt of a very impure quality, obtained by washing certain soils.

In the Madras Presidency a small quantity of spontaneous salt is obtained at Kistna (Masulipatam), Tanjore, and Madura, but the quantity made is declining, as the following figures will show:—

	Maunds. (82lbs.)		Maunds. (82lbs.)
1877	6,072,640	1884	6,036,084
1878	5,897,414	1885	4,904,282
1879	5,231,531	1886	3,109,802
1880	5,614,969	1887	2,076,575
1883	5,871,446		

The mines of Mandi and Kohat, in Northern India, produce about 550,000 to 600,000 maunds (say 2,000 tons), Kohat producing four-fifths of this.

About 1,500 tons of salt are brought into India by Thibet; but, though imported free of duty, it is not profitable to bring it down to the plains in competition with Indian salt, which has to pay the duty of two rupees a maund of 82 lbs.

The Indian export trade in salt is large and increasing, averaging now about 50,000 cwt. It is sent principally to Upper Burma, Nepal, and Kashmir. That taken by Kashmir and Nepal has to pay the Government duty of two rupees per maund. That which goes to Kashmir is Punjab rock salt; that exported to Nepal is mostly, if not altogether, Sambhar lake salt, and in either case the duty is paid at the mines or the lake before removal. The salt sent to Kabul and Bajaur is the gray salt of the Trans-Indus districts, which, for political reasons, pays only half the duty, or eight annas the maund.

The salt taken to Upper Burma is all either Cheshire, Italian, or Sicilian salt, which pays a duty of three annas per maund, when taxed for consumption in British Burma; and of one per cent., *ad valorem*, at Rangoon, when forwarded to Upper Burma. It is sent up the Irrawaddy in the flats of the Flotilla Company.

The imports of salt into India have increased in quantity from 274,000 tons in 1879, to 424,000 tons in 1888, but the average value per ton has fallen from £3 to £1 10s.

The comparative consumption of salt in different districts is shown by the duty paid to have been as follows:—

	1887. Maunds.	1872. Maunds.
Bengal	10,427,899	4,251,759
Northern India	7,597,104	7,835,584
Madras	7,706,796	6,502,137
Bombay	6,236,803	3,501,892
Sindh	229,702	170,819
Lower Burma	1,573,686	503,094
	33,771,990	22,783,285

Extensive salt-fields exist at Shimpagah, a short distance above Mandalay, on the western bank of the Irrawaddy River. It is also obtained at other places in Upper Burma on a small scale. Imported salt is, however, taking its place. The hill people mix the native salt with European salt.

Imports of Salt into India in the Financial Years ending March.

	Tons.		Tons.
1866	186,233	1878	254,231
1867*	162,086	1879	274,180
1868	245,286	1880	352,238
1869	266,566	1881	373,376
1870	272,818	1882	357,224
1871	227,610	1883	338,065
1872	306,839	1884	383,089
1873	276,747	1885	412,839
1874	279,246	1886	363,088
1875	277,085	1887	416,592
1876	365,252	1888	423,897
1877	293,776		

1888-9, 8 months, ending November, 266,375.

From the following figures it will be seen that foreign countries now supply one-fourth of the salt imported into India.

	From United Kingdom. Tons.	Other Countries. Tons.
1881-82	308,636	45,588
1882-83	296,228	41,837
1883-84	302,752	80,337
1884-85	300,665	52,174
1885-86	297,161	65,927
1886-87	293,906	122,686
1887-88	339,651	84,246

Imports of Salt of Indian Manufacture into the various Provinces of India, in tons, in the last five years:—

	1883-84	1884-85	1885-86	1886-87	1887-88
Bengal	20,644	16,256	20,933	20,725	24,600
Bombay	49,703	47,730	48,375	45,862	47,245
Sindh	214	182	188	306	248
Madras	33,339	34,646	36,497	42,596	41,802
Burma	2,211	2,273	2,624	2,863	2,854
Total	106,111	101,087	108,617	112,352	116,742

* Eleven months.

Exports of Salt from India in Hundredweights.

Years ending March—				
Districts.	1879.	1880.	1881.	1882.
Upper Burma	264,240	411,279	417,847	244,343
Kashmir	79,016	75,654	109,333	52,024
Nepal	76,597	83,085	86,407	94,074
Kabul	77,863	72,947	69,609	52,217
Bajaur	41,442	39,467	31,515	28,537
Total	439,156	682,432	714,711	501,194

In 1884 it was 650,624 cwts.

Salt lakes, salt mines, and salt deserts are common in Persia. There is an extensive area on the shores of the Persian Gulf abounding in a large deposit of salt, which crops out at various places on the surface, rising up into ranges of rocks of no little magnitude. There is an average annual export of from 25,000 to 30,000 tons of salt from these mines, which is shipped by native boats to Muscat, and thence by vessels to Bengal, Zanzibar, Mauritius, Balavea, &c.

The only noticeable feature in the Indian trade is the commencement of large imports from Aden, where, under concessions granted by the local administration, an Italian company has commenced to manufacture on an extensive scale.

Imports of Salt into India from Arabia.

	Tons.	From Aden. Tons.
1884	15,561	—
1885	20,107	—
1886	15,153	—
1887	27,943	2,325
1888	42,633	15,004

Salt is found in many of the provinces of China, but its collection is attended with great restrictions on the part of the Government. Twenty years ago the salt proprietors of Cheshire and Worcestershire memorialised the Foreign Secretary, with the view of obtaining an opening for British salt into China. Assuming the population at 300 millions, the quantity consumed there must range between one and two million tons, but even at the present time we ship none there, although many of the ports of the Chinese Empire are now open to us. Salt is an imperial monopoly in China, and its import is strictly prohibited by the treaties, but much is smuggled in between

Burma and Yunnan. The privilege of importing British salt into India was only conceded practically in the year 1846, and it has been so far successful as gradually to lead to an import of about 400,000 tons.

Our home production, of over two million tons of salt per annum, affords employment to a large number of labourers and artisans, besides payments to railways and shipping, &c.

In the Malay and Philippine Archipelago but little salt is made by solar evaporation, except on some parts of the northern coast of Java, and the province of Pangasinan on the western side of Luzon. This no doubt arises from the absence of coast suited for the formation of salt pans (it being skirted with mangroves), and the want of sufficient heat, accompanied by drought, for evaporation. In Java, salt is subject, I believe, to an excise tax by the Dutch Government.

Africa.

For Africa I can furnish but little precise information as to salt production and consumption, the details available being very vague. On the West Coast, salt is very plentiful at Loango, being obtained from many salines; there are also some at Benguela and Bamba, on the Congo. The salt lakes at Gandiole, at the mouth of the Senegal, are famous. They are 1,200 to 1,800 feet long by 600 to 800 feet broad; the salt produced is excellent, and supplies the French colony and the interior. In the Sahara, mines of rock salt furnish Timbuctoo and Central Africa.

Algeria is very rich in mines of rock salt, as well as salt lakes and marshes, where the evaporation in spring deposits thick beds of crude salt. About 14,000 tons of salt are obtained from some of the springs yearly. In the province of Oran some salines yield 6,000 to 8,000 tons; and in the province of Constantine coarse salt to the value of £6,000 is obtained.

In Egypt, the salines of Damietta and Rosetta are the most important, producing about 385,000 bushels, and those of Souakim could produce 28,000 tons. In Nubia, the oasis of Selineh is remarkable for its beds of rock salt, which are worked annually by the wandering Arabs of the neighbouring countries.

In Abyssinia, a good deal of rock salt is met with in the plains at the foot of the eastern mountains. Indeed, there is a plain of salt in a deep valley situated between mountains about two days' journey from the coast. The country is, in fact, nearly covered with salt, which, shaped into small squares, serves as a medium of currency in parts of Central Africa.

There are salines at Breja, on the coast near Tripoli, and there are others of considerable importance near Benghazi. In Tunis the local production supplies all the salt wanted for consumption.

Salt is brought down, during the season, from East Arabia to Zanzibar by Arab dhows, and is heaped up for sale on a strip of clear ground under the eastern face of the fort. It is of two kinds; the fine rock salt, and an inferior kind, which is dark and sandy, and sells at about half the price of the former. On the coast the principal ports and towns supply themselves with sea salt, evaporated in the rudest way. Pits sunk near the numerous lagoons and back waters allow the saline particles to infiltrate; the contents, placed in a pierced earthen pot, are allowed to strain into a second beneath; they are inspissated by boiling, and are finally dried in the sun, when the mass assumes the form of sand. This coarse salt is sold after the rains, when it abounds, for its weight of *holcus* (millet); when scarce, the price is doubled. In the interior there are two great markets, and the regularity of communication enables the people to fare better as regards the luxury than other parts of Africa, where of a millionaire it is said "he eateth salt."

Near Lugowa, in Uvinza, salt is procured in the following rude manner from some muddy swamps:—A quantity of mud is placed in a trough having at the bottom a square hole partially stopped with shreds of bark, beneath which about half-a-dozen similar vessels are placed, the upper one only containing mud. Hot water is then poured into this topmost trough, to dissolve the salt with which the mud is impregnated, and the liquid being filtered by passing through the bark in the holes of the lower troughs, runs out of the bottom very nearly clear. It is then boiled and evaporated, leaving as a sediment a very good white salt. If the first boiling does not produce a sufficiently pure salt, it is again dissolved and filtered, until the requisite purity is obtained.*

In the Island of Madagascar salt is abundant, and on the western coast mines of rock salt are found.

British Colonies.

Finally, we may glance at the production and consumption of salt in the British Colonies. Besides Canada, already noticed, several

* Cameron's "Across Africa," chap. 13.

other of our colonies produce salt, anong others Turk's Island, the Bahamas, Cyprus, the Cape Colony, and Ceylon.

Salt raking is an industry of some importance in *Turk's Island* and Caicos, the quantity annually gathered ranging from 1,500,00 to 2,000,000 bushels. Salt Bay and East Harbour are other shipping ports. There is a royalty on salt of 10 per cent. *ad valorem*. The merchants have of late years put up mills for grinding the coarse salt to a fineness suitable for curing fish, and much is sent for this purpose to Nova Scotia.

Running through the island of Grand Turk the longest way, is a sag or valley, in which are located the salinas and salt ponds. The north-west side is skirted with a beach, but not so high as that on the north-east side. The land on which the ponds are located is on a level with the sea. A canal, neatly walled with stone, conducts the water from the sea to a reservoir, which feeds the "pans" when needed, or when the elements have converted the sea water into brine strong enough to be used in the pans.

There are two kinds of saline resources for the conversion of salt water into salt. One kind may be called a "saline" proper, and the other a "salt pond." The latter has a never-failing supply of water, being fed by springs of salt water.

A saline proper is a flat, and it may contain a few acres or a great many, and is supplied with water from the ocean by the canal already named, which can be opened or closed at will. The first water let in from the ocean goes into a large reservoir, which holds about half as much as the entire area of the salina. The water remains in this receptacle some weeks, evaporation continually going on by the action of the wind and sun. When it reaches 60° or more, as measured by a salometer—salt water being between 10° and 12°—it is fit to be turned into the division called pans, which is done either by hand water-wheels or windmills. At 60° all foreign matter held in solution is precipitated.

The "pans" vary in size, but generally are from one-eighth to three-fourths of an acre in area; are laid out so as to allow watercourses between each for the purpose of obtaining a supply of "brine" from the main reservoir. The divisions are separated by walls made with stone and mud. These are about two feet high, with a width from three to four feet. These "pans" are generally "raked down," and the *debris* thrown out once a year. This is called "cleaning pans."

The brine seldom crystallises into pure salt unless there has been a month's absence of rain. It becomes a saturated solution at 96°, and commences to crystallise at 110°, as measured by the salinometer. To be gathered, the salt has to be broken up by hand by an instrument called a "break-up. It is then raked into rows, to be carted into piles or heaps, some of which contain as many as 10,000 bushels. The pans yield from 5,000 to 8,000 bushels per acre during the season. The canal has to be opened sometimes at low water, to prevent an overflow of the pans from the reservoir after a rain.

A salt pond is distinguished from a salina by having a basin or a spring of salt water in the centre, and has its pans on a little higher ground. The basin is also a reservoir whose water is evaporated, and becomes brine sooner or later, according to the state of the weather. The methods of manufacture are about the same in the two classes. Care must be taken to have the water as pure as possible.

In the *Bahamas* the salt industry was formerly one of the most important pursuits, and almost every one of the islands had its salt lake. At Inagua the salt works are stated to have cost as much as £20,000, and enormous quantities used to be made there, and in the other islands, for export to America, but the duty now imposed upon this article by the United States Government has crippled this industry.

I may mention here that Curaçoa furnishes salt, and in the island of San Domingo there is said to be a mountain more than nine miles in length, and one-half to three-quarters of a mile in width, of a height of from 100 to 700 feet, composed of solid layers of salt, nearly pure and ready for use.

The salt monopoly brings in a revenue in the island of Cyprus.

The manufacture of salt is, in several of the colonies, an important branch of chemical industry. At the *Cape of Good Hope* salt is obtained from subterranean layers, and there are several places where it is worked. At one of these, near Uitenhage, the "salt-pan" is three miles long and a mile broad, and it has been valued, for rateable purposes, at £18,000. The pan is a depression about 40 feet deep, where rain water collects and dissolves the salt. The salinated solution is drawn off into evaporating pans to crystallise. The annual accretions are about an inch thick,

and easily distinguished by the interposition of thin layers of mud. In summer, when the water is nearly evaporated, the loose particles of salt are blown about by the wind, and collected in small wreaths as pure and as white as driven snow.

No shaft has been sunk to test the thickness of the deposit. The salt is used for local consumption, but large quantities are also imported from Cheshire every year.

In the district of Middlesburg, between the village of Maraisburg and the Fish River, there are three salt pans, each with an area of 400 or 500 acres. At one of these the salt is raised and evaporated in artificial pans, thereby securing an increased and constant supply of a quality equal to any imported.

There are, in all, 48 pans in the colony, which produce about 300,000 bushels per annum. The price varies in different localities from 2s. to 20s. the muid of 3 bushels.

In *Ceylon*, salt is a considerable source of revenue, and is carried on as a monopoly of the Government. The manufacture is mainly conducted by two Government establishments on the west and south coast of the island. The salt water is drawn from an extensive lagoon, about 28 miles long, and from 4 to 8 miles broad. The water within this lagoon evaporates under the influence of the sun and wind, so that it becomes considerably denser and more concentrated than sea water. The collection of salt usually takes place twice in the year, the first operation is to enclose a certain area of the lagoon by means of a dam, so as to exclude the influence of the tides, while encouraging evaporation, and enabling the organic impurities to settle in the pure water. After a certain time, the water is drawn off into shallower and smaller basins, when the evaporation is still more rapid, and subsequently into the crystallizing beds, where the salt is deposited in crusts, varying from one to two inches in thickness, and is then drawn out. At the factory on the west coast the out-turn varies from 50,000 to 500,000 cwt. yearly. The work is carried on by contractors who own the land, and under the supervision of Government officials.

In Victoria, some years ago, a company mauufactured salt by natural evaporation, at the lakes near Cressy, about 45 miles from Geelong. Large quantities were brought in and taken for consumption in the colony, but after the gold-field discoveries the manufacture was given up.

The imports of salt in Victoria were 8,226 tons in 1885, and 10,346 tons in 1886; of this, 500 or 600 tons were rock salt.

The imports in New South Wales are about 15,000 to 16,000 tons annually, of which about 2,000 tons are rock salt.

A seam of rock salt forty feet thick was discovered near Scone, in New South Wales, a few years ago, but I have not heard that it is worked.

Our exports of salt to Australasia are on the increase; last year they reached 67,603 tons, nearly double the quantity of 1886.

Many of the colonies levy a duty on imported salt. In the Australasian colonies, Victoria, New South Wales, Western Australia, and Fiji, the duty is 20s. a ton; in South Australia, 25s. a ton; in Tasmania, 30s. a ton, except rock salt, which is admitted free. Queensland and New Zealand charge no duty on salt. In India it is 5s. 5d. a cwt., and in Burma only 6d. a cwt. The Cape of Good Hope charges 3d. the 100lbs.; Natal, 5s. a ton, and 2s. on rock salt. In West Africa, at Gambia and Lagos, the duty is only 3d. a cwt. Canada charges 5d. and 7½d. a cwt. on foreign salt; Bermuda, 5 per cent. *ad valorem*; Jamaica, 1s. 1d. a cwt.

I fear I must have wearied my audience with so many figures. I have thus taken an imperfect but comprehensive glance at the salt production and consumption of various countries, which will at least have convinced us that the collection and utilisation of this mineral is an important industry, whether we look at it simply as a necessary condiment, or taken in connection with its other multiplied uses. There are no doubt gentlemen present from different distant countries who can, perhaps, correct me in some points, and also supplement the details which I have given.

DISCUSSION.

Mr. ROBOTHAM said he might perhaps be permitted to bring to the notice of the meeting a deposit of salt in a lake about 242 miles inland from Los Angelos, in California, which had not been referred to by Mr. Simmonds. This was a most remarkable deposit; the lake was thirteen miles long and eight miles across, and the deposit of salt extended for about a distance of five miles by two miles. The salt was very pure, and had never been touched. There were a great number of these lakes, not only in California but in Nevada and Utah, and the natural salt was found upon the surface of the

land. He believed he was the first Englishman that visited this lake, and in getting there he had to go a distance off the main road of forty-two miles. The lake was completely surrounded by mountains, and in getting to it you had to pass through a long cañon, and for two miles he was walking upon one to two feet of salt. There were a great number of these lakes in other parts of the world —for instance, he had seen the same thing in Thibet. Wherever borax was found in solution you generally found salt. He had seen borax deposits in Italy and Turkey, though in Turkey he had not found any salt. With regard to the lake to which he had already referred, and of which he had a photograph, he might say that it would not pay to export the salt, as it would cost more to put it in a cart and take it to the place where it could be used than it would to send salt from England to California. In the neighbourhood of this lake the climate was horrible, so that no one cared to reside there. Water, for drinking, could not be oblained within seventeen miles, and, in fact, the whole country was uninteresting. He believed that Nevada, Utah, and California were capable of producing as much salt as the world required.

Mr. SIMMONDS said he had omitted to state in his paper that he was under obligation to the Messrs. Corbett for the specimens of salt upon the table, and for much valuable information.

Mr. J. W. FOX said he had been associated with the salt trade for many years, and he had listened with great interest to the paper, containing as it did a vast amount of information. He thought the great advantage this country possessed for producing salt was the fact of cheap fuel. Of course they were indebted also to the facilities for carrying it, and to the ports from which it could be exported; and had it not been for these facilities England would not have been able to supply the foreign markets to the extent it now did. At the present time ships carried salt as ballast from this country to America, with the view of returning with a cargo of wheat, and had it not been for free trade this important advantage would not have been obtained. One point of great interest to the trade was the large demand for salt for India; of the 400,000 tons consumed there, 300,000 went from this country. No doubt the consumption of salt in India ought to be greater than it was, and if the duty were removed the consumption would largely increase. If the Indians consumed more salt their health would be improved, the cattle would be more abundant, and the land more fertile. It was a great misfortune that the salt tax had been looked upon by financiers as a ready source of revenue. No doubt it possessed one merit, viz., that it was impossible to evade it, but when you had an impoverished people it was a question whether it would not pay better to liberate them from a tax of this kind, and look to a revenue from other sources. Some years ago the Indian Government offered a reward of £25,000 to anyone who would suggest a means by which salt could be so far treated as to render it unfit for human food, and at the same time acceptable for cattle and fit for manure, but up to the present time no one had claimed this reward. In France they mixed the salt with various kinds of earth, making it into the shape of a brick, the object being to evade the duty, but the addition of earth added considerably to the cost of transport. He did not think, looking at the statistics given in the paper, that England ran much risk of being in want of salt, and that the scare which had lately been started was quite unfounded. Mr. Simmonds had not explained how the enormous deposits of salt came to exist; he had described that six layers of salt were founded at different depths, from which it might be imagined that these layers were the result of six successive eruptions of sea water. If so, it gave one an astonishing idea of the changes which must have occurred, seeing that sea water only contained a certain per-centage of salt.

Mr. H. B. FULTON said no reference had been made to Cadiz, where salt was largely produced, and he had seen hundreds of pyramids heaped up there. Salt was also produced at Cyprus, and he believed it could be produced there more cheaply than in any other part of the world. At present it produced 100,000 tons a year, which were sufficient for the population. Formerly the Government derived a revenue from it of something like £37,000 a year. This revenue at the present moment had fallen to £3,000. The original amount was taken in consideration in fixing the tribute payable by this country to Turkey, and although the sum had fallen off lately, there was no reason why it should not be increased if proper means were taken for the export of the salt, such as by the erection of a jetty near the salt lakes. If this were done, and better accommodation provided, salt could be put on board ship for something like 10s. a ton. Considerable expense was now incurred in the payment of guards to watch the place; and large wages were paid to these guards in order to prevent people from taking away a pennyworth of salt. This was a subject which deserved careful consideration.

The CHAIRMAN proposed a vote of thanks to Mr. Simmonds for his interesting paper, which was put and carried unanimously.

Mr. SIMMONDS, in responding, said that although he had not referred in the paper to the means employed for rendering salt unfit for human food,

he was aware of the process adopted in France. Attempts had been made in many countries with the same object, but so far as he was aware none up to the present had been found to be practicable.

General Notes.

Canal Navigation.—Mr. A. Pickard will exhibit models of his new system for canal navigation, in the Library of the Society of Arts, on Wednesday evening, February 20.

Jewish Population of the World. — The French edition of the *Levant Herald* quotes from the *Annuaire des Archives Israélites* the following statistics of the Jewish population of the world:—Europe contains 5,350,000 Jews, distributed over the different countries in the following proportion—France, 63,000; Germany, 562,000 (Alsace-Lorraine, 39,000); Austria-Hungary, 1,644,000 (Galicia, 688,000; Hungary, 638,000); Italy, 40,000; Netherlands, 82,000; Roumania, 265,000; Russia, 2,552,000 (Russian Poland, 768,000); Turkey, 105,000; other countries, 37,000 (Belgium, 3,000; Switzerland, 7,000; Bulgaria, 10,000; Denmark, 4,000; Spain, 1,908; Gibraltar, 1,500; Greece, 3,000; Servia, 3,500; and Sweden, 3,000). Asia contains 300,000 Jews, distributed as follows:—195,000 in Asiatic Turkey (Palestine, 25,000); 47,000 in Russia in Asia; 18,000 in Persia; 14,000 in Central Asia; 19,000 in India, and 1,000 in China. Africa has a Jewish population of 364,000 (800 in Egypt; 55,000 in Tunis; 35,000 in Algeria; 60,000 in Morocco; 6,000 in Tripoli, and 200,000 in Abyssinia). America contains 250,000, of whom 230,000 inhabit the United States. Oceania has only a Jewish population of 12,000. Thus the Jewish population of the whole world amounts to a total of 6,300,000.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday evenings at Eight o'clock:—

February 20.—"The Forth Bridge." By Benjamin Baker, M.Inst.C.E. Sir Frederick Bramwell, Bart., F.R.S., will preside.

February 27.—"The Irish Lace Industry." By Alan S. Cole. The Duke of Abercorn, C.B., will preside.

March 6.—"Arc Lamps and their Mechanism." By Prof. Silvanus P. Thompson.

March 13.—"Aluminium and its Manufacture on the Deville Castner Process." By William Anderson, M.Inst.C.E. Prof. Sir Henry Roscoe, F.R.S., will preside.

March 20.—"Motor Trials of the Society of Arts, 1888." By Prof. A. B. W. Kennedy, F.R.S.

Papers for which no dates have as yet been fixed:—

"Automatic Selling Machines." By J. G. Lorrain.

"Secondary Batteries." By W. H. Preece, F.R.S.

"The Use of Spirit as an Agent in Prime Movers." By A. F. Yarrow.

Foreign and Colonial Section.

Tuesday evenings, at Eight o'clock:—

February 19.—"Slavery in its relation to Trade in Tropical Africa." By Commander V. Lovett Cameron, C.B., R.N. The Earl of Dundonald will preside.

March 12.—"Borneo." By Robert Pritchett.

Applied Art Section.

Tuesday evenings, at Eight o'clock:—

February 26.—"English Bookbinding in the Reign of Henry VIII." By W. H. J. Weale. E. Maunde Thompson, D.C.L., F.S.A., Principal Librarian to the British Museum, will preside.

March 19.—"The Art of the Jeweller." By Carlo Giuliano. Sir George Birdwood, K.C.I.E., C.S.I., will preside.

April 9.—

May 14.—"Venetian Glass." By Dr. Salviati

Indian Section.

Friday evenings, at Eight o'clock:—

February 15.—"The Ruby Mines of Burmah." By G. Skelton Streeter, F.R.G.S. Sir Charles E. Bernard, K.C.S.I., will preside.

March 8.—"The Present Condition and the Prospects of Indian Agriculture." By Prof. Robert Wallace. The Duke of Buckingham, G.C.S.I., will preside.

March 29.—"The Progress of the Railways and Trade of India." By Sir Juland Danvers, K.C.S.I.

May 3.—"The Karun as a Trade Route." By Major-General Sir R. Murdoch Smith, K.C.M.G.

May 24.—"Indian Wheats." By John McDougall.

Cantor Lectures.

The following courses of Cantor Lectures will be delivered on Monday evenings at Eight o'clock:—

W. J. LINTON, "Wood Engraving." Two Lectures.

LECTURE II.—FEBRUARY 18.—The Arch of Triumph—Burgkmair's Procession—The Triumphal Car—Sir Theurdank and the White King—Holbein's Dance of Death—The Engravings by Lutzelburger—Their special value—The meaning of *fac-simile*—Stothard and Clennell—Knife-work and graver-work—What is white line—Bewick and his school—Later work—Thompson and Harvey—Decadence—Art and Mechanism — Photography—The American "New Departure."

WALTER CRANE, "The Decoration and Illustration of Books." Three Lectures.
March 4, 11, 18.

C. V. BOYS, F.R.S., "Instruments for the Measurement of Radiant Heat." Four Lectures.
March 25; April 1, 8, 15.

H. GRAHAM HARRIS, M.Inst.C.E., "Heat Engines other than Steam." Four Lectures.
May 6, 13, 20, 27.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, FEB. 18...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. W. J. Linton, "Wood Engraving." (Lecture II.)

Medical, 11, Chandos-street, W., 8½ p.m.

Asiatic, 22, Albemarle-street, W., 4 p.m.

Victoria Institute, 7, Adelphi-terrace, W.C., 8 p.m. Mr. C. S. Wilkinson, "Scientific Research and Revelation."

London Institution, Finsbury-circus, E.C., 5 p.m. Rev. J. G. Woods, "Ants."

TUESDAY, FEB. 19...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Foreign and Colonial Section.) Commander V. Lovett Cameron, "Slavery in relation to Trade in Tropical Africa."

Royal Institution, Albemarle-street, W., 3 p.m. Dr. G. J. Romanes, "Before and After Darwin." II. "Evolution." (Lecture V.)

Civil Engineers, 25, Great George-street, S.W., 8 p.m. Mr. Gisbert Kapp, "Alternate-Current Machinery."

Statistical, School of Mines, Jermyn-street, S.W., 7¾ p.m. Mr. Richard Price-Williams, "The Coal Question."

Pathological, 53, Berners-street, Oxford-street, W., 8½ p.m.

Zoological, 11, Hanover-square, W., 8½ p.m. 1. Mr. R. Lydekker, "A Skull of the Chelonian Genus *Lytoloma*. 2. Mr. R. Lydekker, "An apparently New Species of *Hyracodontitherium*." 3. Dr. A. Gunther, "Some Fishes from the Kilima-njaro district." 4. Mr. F. E. Beddard, "Certain Points in the Structure of *Polyboroides*, with remarks on its Systematic Position."

WEDNESDAY, FEB. 20...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. Benjamin Baker, "The Forth Bridge."

Meteorological, 25, Great George-street, S.W., 7 p.m. 1. Mr. William Marriott, "Report on the Helm Wind Inquiry." 2. Mr. F. A. Velschow, "An Atmospheric Sketch." 3. Ven. Archdeacon Wynne, "The Drought in New South Wales in 1883-4, and Rainfall at Corella, 1879-88."

Geological, Burlington-house, W., 8 p.m. 1. Mr. S. S. Buckman, "The Cotteswold, Midford, and Yeovil Sands, and the Division between Lias and Oolite." 2. Miss C. A. Raisin, "Some Nodular Felstones of the Lleyn Peninsula." 3. Mr. A Johnstone, "The Action of Pure Water, and Water saturated with Carbonic-acid Gas, on the Minerals of the Mica Family."

Royal Society of Literature, 21, Delahay-street, S.W., 1 p.m.

Archæological Association, 32, Sackville-street, W., 8 p.m.

Civil and Mechanical Engineers, Westminster Palace Hotel, S.W., 7 p.m. Mr. J. H. Turner, "The Compression Members of Bridges."

THURSDAY, FEB. 21...Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

Linnean, Burlington-house, W., 8 p.m. 1. Mr. G. Townsend, "Euphrasia." 2. Mr. C. T. Druery, "Sexual Apospory in *Polystichum angluare*.' 3. Prof. R. T. Lowne, "The Retina of the Blow-fly."

Chemical, Burlington-house, W., 8 p.m. Ballot for the Election of Fellows.

London Institution, Finsbury-circus, E.C., 5 p.m. Mr. Wyke Bayliss, "The Legend of Beauty; or, Art as representing the Passion of our Lives."

Royal Institution, Albemarle-street, W., 3 p.m. Dr. Sidney Martin, "The Venom of Serpents and allied Poisons." (Lecture I.)

Telegraph Engineers and Electricians, 25, Great George-street, S.W., 8 p.m.

Historical, 11, Chandos-street, W., 8½ p.m.

Numismatic, 4, St. Martin's-place, W.C., 7 p.m.

FRIDAY, FEB. 22....United Service Institute, Whitehall-yard, 3 p.m. Lord Brassey, "Our Naval Position and Policy."

Royal Institution, Albemarle-street, W., 8 p.m Weekly Meeting, 9 p.m. Mr. H. Crichton Browne "In the Heart of the Atlas."

Civil Engineers, 25, Great George-street, S.W., 7 p.m. (Students' Meeting.) Mr. Thomas A. Guyatt, "Furnaces."

Quekett Microscopical Club, University College, W.C., 8 p.m. Annual Meeting.

Clinical, 53, Berners-street, W., 8½ p.m.

Browning, University College, W.C., 8 p.m. Mr. J. B. Oldham, "Some of the Difficulties in the Study of Browning."

SATURDAY, FEB. 23...Physical Science Schools, South Kensington, S.W., 3 p.m. 1. Dr. J. W. Waghorn, "Note on the Measurement of Electrical Resistance." 2. Prof. S. P. Thompson, "Notes on Polarized Light," (Pt. iii.) viz., (1) a New Polarimeter and (2) the Formation of a Cross in Certain Crystal Structures. 3. Profs. Ayrton and J. Perry, "Electrical Measurement."

Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Lord Rayleigh, "Experimental Optics.' (Lecture I.)

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FRIDAY, FEBRUARY 22, 1889.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

FORTH BRIDGE.

With the present number of the *Journal* is issued as a supplement four plates illustrating Mr. Benjamin Baker's paper on "The Forth Bridge" (see page 289).

TRIALS OF MOTORS FOR ELECTRIC LIGHTING.

The following letter from the Judges accompanied the report printed in last week's number of the *Journal.*—

3, Princes-street, Westminster, S.W.,
25th January, 1889.

Dear Sir,—We have pleasure in enclosing herewith our report, as the judges appointed by your Society, upon the trials of motors for electric lighting made by us for the Society of Arts in September last. With the report we also enclose the various drawings, diagrams, and copies of indicator diagrams which are referred to in it.

We have to point out that the four engines which we have tested belong to three several classes under the conditions of the competition.

The Paxman engine was the only steam-engine and the only engine in Class A. Its performance as to economy of fuel was in every way excellent, its workmanship was also first class. Under paragraph 8*a* of the conditions it left something to be desired, for during the speed trials the governor hunted considerably. We see no reason to suppose that this defect could not be easily remedied. The principal particulars of the experiments on the Paxman engine are given in Table XI.

The Atkinson engine falls into the first group (under 10 h.p.) of Class B, and does not, therefore, compete directly with either of the other two gas-engines. The particulars of its trials are given in Table I., from which it will be seen that it attained a very high economy in gas consumption, and in other respects worked very satisfactorily.

The other two gas-engines, namely the Crossley and Griffin, are both in the second group (over 10 h.p.) of Class B, and therefore are in direct competition. It will be seen from Tables V. and VIII. that the Otto engine running upon the brake (without the counter-shaft) uses much less gas per brake h.p. than the Griffin.

The Otto engine, however, as submitted to us for electric lighting, used so much power in connection with driving its counter-shaft that the consumption of gas *per h.p. available for electric lighting* was practically the same in both engines. The governing of the Griffin engine was distinctly better than that of the Crossley. The consumption of cylinder-lubricant was considerably more in the Griffin than in the Crossley. In both cases the engines ran quite cool during all their trials.

Each of the three gas-engines was tended by one man only during its trials.

We have conferred with your Committee on Motor Trials as to this report and our award, and after consultation with the Committee, we beg to make the following recommendation to your Council:—

As the Paxman and Atkinson engines are each the sole representatives of a class, and have each given exceptionally good results, we recommend that a Gold Medal be awarded to each.

As regards the other two engines, one (the Crossley) has the advantage in respect to economy of gas and of lubricant, and the other (the Griffin) in respect to regularity of speed. In this competition both these points are of the first importance, and considering the general excellence of both engines in other respects, we recommend that a Gold Medal should be awarded to each.

We remain, dear Sir,
Yours faithfully,
(Signed) John Hopkinson.
(Signed) Beauchamp Tower.
(Signed) Alexander B. W. Kennedy

H. Trueman Wood, Esq.,
Secretary of the Society of Arts,
John-street, Adelphi.

CANTOR LECTURES.

The second (and final) lecture of his course on "Wood Engraving," was delivered by Mr. W. J. LINTON, on Monday evening, 18th inst., when he continued his subject from the period of the engraving of the Emperor Maximilian's Arch of Triumph; He passed on to describe Holbein's "Dance of Death," and the engravings of Lutzelburger, and then spoke of the revival of the art under Bewick and his school. The lecturer conclnded with some remarks on the American "new departure," and a definition of the distinction between art and mechanism in wood engraving.

The CHAIRMAN (Mr. Francis Cobb), proposed a cordial vote of thanks to Mr. Linton, for his interesting course of lectures, which was carried unanimously.

The lectures will be printed in the *Journal* during the summer recess.

Proceedings of the Society.

INDIAN SECTION.

Friday, February 15, 1889; Sir CHARLES E. BERNARD, K.C.S.I., in the chair.

The paper read was—

THE RUBY MINES OF BURMA.

By G. SKELTON STREETER, F.R.G.S.

The ruby mine tract of Burma is situated on the hill sides and in the plain lands of a valley running east and west, nestling at an elevation of 4,500 feet in a range of mountainous spurs that run nearly at right angles to the Burmese Yoma. This valley is some 80 miles due north of Mandalay, the capital of Upper Burma, but owing to the grave physical difficulties of the intervening country, it can only be reached after a circuitous journey of 200 miles.

Mandalay has always been looked upon as the base of departure for the ruby mines, to which it is united by three well-known native routes. The first is an overland route through Lamaing and the Shan State of Mainloung; the second by river to Kyan-nyat and across the plains to Sagadoung; and the third is by river to Thabeit-kyan and over a plateau and ascending ridges to the western entrance of the ruby mine valley.

Each of these routes was well considered and tested by actual experience, before it was finally decided to settle upon and develop the Thabeit-kyan road, and by this route we will now leave Mandalay for the mines. An animated scene presents itself to the traveller, as he embarks on the Irrawaddy Flotilla's Bhamo steamer from Mandalay shore in the dreamy light of early morning; ponies and mules are being half dragged, half pushed on board, among crowds of Burmans, Shans returning to their homes, perhaps after some religous pilgrimage, Kachins, Yunnan, and Canton Chinamen going to trade, or to look after their monopolies of jade and rubber, and the polite Panthey, to whom the departure is only one of the every day occurrences of his roving life. Finally every one is on board and the steamer gets under way, and before long passes the Mindoon Pagoda on the opposite bank of the river with its celebrated bell, over 90 tons in weight, and soon we are steaming through some of the most picturesque river scenery in the world. On the eastern bank rise the mountains forming the western boundaries of the Northern Shan States, covered with forests, at this season of the year almost destitute of foliage, but in the summer hidden by gigantic creepers and flowering orchids, while on the western side of the river undulating irregular shaped hills, often crowned with pagodas, form a fitting frame to the lake-like landscape.

If there is sufficient water, and the steamer does not stick on any of the numerous shifting sandbanks which infest the river, Thabeit-kyan, the landing point for the ruby mine district, is reached in a day and a-half.

Thabeit-kyan never appears to have been more than a fishing village and a depôt for the ruby mine caravans, though a few old gold workings exist in the neighbouring streams. Changing the steamer now for pack-ponies and coolie transport, we leave the village, and a sharp ascent of 1,200 feet leads up to a plateau which extends 11 miles to Wapyudoung over a good level road, through eng jungle; the track then runs over a ridge, and descends to the Nampan stream, the gravelly bed of which is mixed with innumerable tiny crystals of spinel; another steep ascent of some 3,000 feet leads to Schwee-yaung-bin, or the village of the golden pagoda tree, so called from its containing an immense pepal tree, on which every

traveller or trader used to place a piece of gold leaf as an act of veneration as he passed along the road.

Schwee-yaung-bin was the head-quarters of a powerful Shan headman, an active opponent to our interests at the commencement of the British occupation; he, however, came in when the Chief Commissioner visited the district, and undertook postal, transport, and other contracts, which he performed for several months faithfully, and then suddenly bolted. It was then discovered he had been most unmercifully squeezed by one of the native local Government officials, who had almost ruined him; and at the date of my leaving Burma he had not returned, in spite of all endeavours and promises of restitution. Leaving Schwee-yaung-bin, the path winds through a most picturesque country devoted to *toung-lat* cultivation, which are made by clearing the timber from the sides of a hill slope, burning the fallen trees, and planting rice and other cereal crops; in the patch cleared, a small hut is built on posts, high above the ground, in which the husbandman sits, smokes his cheroot, and watches his harvest ripening, protecting it from the inroads of elephants or buffaloes. These clearings, as a rule, will bear only two crops, owing, I believe, to the fertilising properties of the ashes becoming exhausted. A sharp descent leads down to the Kin river, which has been effectually crossed by a suspension bridge, hung on a cable which was ordered by King Theebaw, some years back, from Europe, with the idea of running it along the bed of the Irrawaddi to Bhamo.

After crossing the Kin river, a distance of 40 miles from Thabeit-kyan, the ruby mine tract proper may be said to begin. The path winds round a hill known as Khabine Toun, dominated by peaks of black gneiss rocks, a typical feature of the district we are entering. Ascending the rolling ground, and passing through country in the middle of which five or six mining or agricultural villages peep out from their graceful surrounding of pagodas, banana trees, and monasteries, the plain lands of Kiappien are reached, which form the western end of the ruby valley. After another eight miles' march by winding streams, generally discoloured by the red clayey earth from some neighbouring washing, and through woods of grand trees, the town of Mogok, the administrative centre, both in former times and now, of the ruby tract, is entered.

The history of the district we are now in is lost in the domain of early Shan legends, but there is no doubt that these mines have been worked for hundreds of years. One of the seven sons of Kun-Lung, the founder of the Shan Dynasty, in the 6th century, is said to have ruled a State, probably Momeit, near which ruby mines existed, and his tribute to the central government was fixed at two viss, or about 7 lb. of rubies yearly. The Burmese probably did not acquire the mines till about the 16th century, but when once these passed into their possession they appear to have kept a firm hold upon them, notwithstanding the various vicissitudes of their other Shan territory. The early European travellers who visited Burma at the end of the 15th and in the 16th century make frequent mention of the mines, describing them as north of the capital, "where grow rubies and many other precious stones." An Italian, who was in Burma about 1510 A.D., received from the king, in return for a present of coral, 200 rubies, which he valued at 100,000 ducats, and this caused him to describe the donor as the most liberal king in the world. None of these travellers were allowed to visit the mining district, and the first European who saw them was probably a runaway English sailor, who was in the employ of King Phagyidoa, in 1830, and who was sent to blast a certain rock at one of the royal mines at Tapambin. Some of the present elders of the district still remember this man, and told me some amusing stories about his eccentricities; and I believe he must have died at the mines, or been quietly made away with, for I could find no account of his return to the capital. The district was again visited in 1881 by a party of Frenchmen under an engineer in the king's employ. And these appear to have been the only Europeans who personally knew the mines before our arrival on December 26th, 1886, after a tedious and dangerous march of two months through unknown malarious jungle, and over difficult mountain passes. I think we all felt amply repaid for our hardships on that day, when we beheld our long-sought-for goal, stretching at our feet some 3,000 feet below us; not as a barren, treeless waste, as many, from former visits to mining centres expected, but a picturesque valley, high hills on either side and beyond range after range of mountains lost in the blue mist of the distance.

The main characteristic of this ruby valley is its division by a spur running down from one of the northern peaks, raising the plain

lands on the western side 800 ft. above those on the eastern. A labyrinth of smaller hills and spurs divides the tract into a series of little valleys or basins which, however, broaden out at the ends of the valley proper into considerable stretches of plain lands; and the peculiarity of the district is that the rubies appear principally to be distributed along the northern slopes; those found in the plains and southern sides of the valley, showing indications of having been washed down from the northern hills. The mines, which are scattered over the whole district, may be divided into five classes, but before describing them in detail, it will be well to glance at the geological features of the valley. The rocks of the district are composed of gneiss with interbedded granular limestone, the supposed matrix of the ruby. Through the action of the rain and atmosphere, portions of these gneissose rocks have been disintegrated while the limestone has been decomposed and dissolved, and the resulting materials washed down the mountain side, forming flanks of various thickness of red or pink clayey material, with a few scattered boulders of hard undecomposed rock, the minerals contained being liberated and distributed through the clay. These deposits or flanks have again been partly washed down by the mountain streams and rains to the plain portion of the valley, where they have been mixed with alluvial material brought by the larger streams flowing through it, and the turning to advantage of these natural influences has brought into use the different systems of mining found in operation on the annexation of Upper Burma.

The first description of mine is known by the name of Ludwins, from *Lu* (cave) and *twin* (pit); and though there are now only eight of these mines at work, the number of old abandoned cave workings met with in the district shows the value attached to them in former times. The most important mine of the class now working is near the village of Baumadan, north of Kathey. This village lies in a deep hollow, protected on two sides by vertical cliffs, which rear up tier after tier, the earth that once surrounded their blackened peaks having been removed in the eager search for the treasure it contained. Half way up these cliffs, in a natural cutting, is the entrance to the cave working, which is said to extend 200 feet beneath the rocks. Rough stone platforms have been constructed on the sides of the cutting, on which are built the native miners' huts. Small galleries or tunnels, just large enough for the men to crawl along, have been made through the fissures and the softer or disintegrated parts of the rock, until a lode of the decomposed limestone has been struck, or a vein of gravel. This earth or gravel is brought to the surface and carefully washed, and appears to be naturally concentrated, sometimes containing as much as 25 per cent. of rubies. A mine of this description generally gives satisfactory yields for a certain period, and then the men are stopped by falls of rock or choke-damp, and are compelled to abandon the workings having neither the knowledge nor the means to overcome the difficulties, which would scarcely embarrass practical European miners.

The second kind of mines are known by the name of Myawdwin, or hill-side workings, and extend along the whole northern face of the valley; their position depending as much on the adaptability of the ground for bringing a sufficient head of water to work them as on the stratum of the soil itself, for nearly the whole face of the northern slope contains ruby-bearing earth. The myaw working is a primitive system of hydraulic mining. An open cutting on the hill side is chosen, the lower end of which opens on to a gully. Water channels are then constructed by digging trenches to conduct the water from one of the mountain streams, often at a considerable distance along the hill side to the cutting. Where a ravine intervenes, a timber aqueduct is run across, the trough carrying the water being supported by poles held together by strong cross pieces and stays. The water is delivered at the top of the cutting, and flows away through a trench at the bottom, which forms a kind of sluice. The earth is excavated from the sides by hand and thrown into the sluice, the scattered masses of rock, when small enough to handle, being used for banking the trench and forming platforms for refuse. The water falling in a heavy shower on the earth softens the stuff and carries away the clayey particles, while the sand and gravel are held by riffles placed across flumes at the lower end of the trench; this concentration is again puddled, the larger pebbles thrown away, and then carefully searched for rubies and other precious stones. This process of working is often a dangerous one, owing to the want of proper precautions. The sides of the cutting become undermined, and the banks fall in, bringing with them great quantities of the loose top soil, rocks, trees, and other *débris*, burying the unfortunate miners. One of these slips

occurred when I was at Mogok last February, and instead of the native mine licensee endeavouring to extricate the six unfortunate men who were buried, he stopped all work and took his men away, saying the evil spirit was about, and the corpses were not recovered for some two days after. Probably, however, if there had been any chance of the men being alive, exertions would have been made to dig them out; but, according to all the native accounts, these accidents are fatal, and death is almost instantaneous.

The third system of mining is known as *twinlone*, or pit mining. This is carried on in the plain portions of the valley, shafts being sunk through the alluvial deposits till the ruby-bearing earth is reached, at a depth varying from 15ft. to 30ft. Bamboo levers on poles are then fixed round the mine, with rattan ropes and buckets attached, and these continually rise and fall as they are filled by the miners beneath with the "byon" or ruby earth, or with the water that permeates through the sides of the working. When all the ruby earth has been extracted the shaft is abandoned, for the miners will not work through the soft clay underneath, which breaks through their timbering; and it is still an undiscovered problem whether another layer of "byon" exists below. These plain mines are often filled in and cultivated with the surrounding patches during four months of the year, and many parts of the ground have without doubt been turned over several times, and still appear to repay for working.

The fourth system of mining may be called river workings, the natural difficulties of which have been, as a rule, greater than the native mind could grapple with. The most intelligent of the inhabitants of the district have a great belief in the richness of the deposits in the river beds that run through the valley, and I have often heard them lament over their inability to handle them. King Mindohn Min is said to have sent to Mogok a Burmese engineer to suggest some scheme to overcome these difficulties, but no steps were taken in the matter, owing to his death occurring shortly after his arrival, a fate, curiously enough, which appears to have overtaken most strangers who entered the mining region before British occupation. The present *modus operandi* is by running a dam across a portion of the river, and in the still water formed beneath, to either extract baskets of the gravel by hand or by diving, according to the depth. That rich and concentrated deposits are there is almost certain, for I found layers of "byon" in Mainloung territory some distance from the ruby mine tract, brought down during the rainy months through the gorge that drains the district, and deposited in banks on the river side.

The fifth and last description of working may be termed quarry mining. A limestone cliff is selected, and masses detached by blasting, broken by hammers, and the inclosed rubies chipped out; owing, however, to the rudeness of this method, the rubies extracted are more or less shattered, and only a few of the miners think the results equal to the trouble, as compared with the previous system described.

Such, then, are the different modes of procuring those Oriental rubies that have at present appeared in Europe, and show the primitiveness of the systems used as compared to our higher knowledge. Nevertheless, much skill and ingenuity has been displayed in the different workings, and the results are highly creditable to the miners, when the limited means in their hands are taken into consideration.

I should have liked to have been able to have given you a description of the same country worked with scientific appliances; but although machinery is on its way out, it will not probably commence running before November, the end of the rainy season, owing to the impassable state of the road, and I must leave you to judge for yourselves the scope there is in the district for methods of working of a scientific character combined with skilled management.

A description of the ruby mine tract would not be complete without some account of the people who inhabit it; and the variety of races collected within the area provide matter of great interest to the ethnologist. To account for this, it must be remembered that the district borders the early centres both of the Burmese and Shan kingdoms, viz., Tagaung and Maingmau, was inhabited before the overflow from these kingdoms permeated down the courses of the Irrawaddi, Salween, and intervening rivers, and mingled with surrounding races, and the district is still rich in legends, many of them mythical, relating to these early days. It is also near the principal highway used in the invasions of Burma by the Chinese, and scattered or defeated bands of both armies have drifted into the valley and finally settled there. Again, in more modern times, gangs of prisoners from con-

quered States have been sent to work at the mines, and by their tractability have become free, and formed communities of their own.

The majority of the inhabitants may be classed as Burmanised Shans, living in Mogok, Kiappien, and the villages round, in substantial wooden houses, with a considerable amount of comfort. Mogok itself seems always to have been the commercial and political centre of the district, and its public buildings, as represented by monasteries, rest-houses, and temples, afford good examples of the energy, skill, and affluence of its people. They are Buddists, but their religion has lost many of its purer doctrines by the introduction of Shan beliefs and spirit worship. The monks are never seen collecting their daily means of sustenance from the townspeople, as in the cities on the plains; and their surroundings show that they are not above ordinary creature comforts or even luxuries. They are, however, hospitable and intelligent, and I have always met with kindness from their hands when circumstances have compelled me to take up quarters for the night in their dwellings. Several of them are great travellers—if we may distinguish those who travel on their own feet from those who are carried by steam—having visited many of the cities of Yunnan and the surrounding Shan States. The monks here, as seems to be the universal custom both in Burma and the Shan country, are the village schoolmasters, and appear to exercise a beneficial control over their pupils, and when one of these dignitaries die it means a period of mourning—or perhaps I should say rejoicing—to all classes of the community. Feasts are held, crackers let off on every available occasion, an elaborate funeral car is constructed, ornamented with pictures, tinsel, and cloths specially procured from Mandalay, and at the new moon the embalmed corpse is placed upon it, and drawn to a selected spot and publicly burnt. These funerals mean a general holiday for a fortnight, for every man, woman, and child give what assistance they can, and abandon their ordinary work, and the expenses of the funeral often amount to over Rs. 20,000. The residents of Mogok and Kiappien rarely do any heavy labour at the mines themselves. They engage men from the smaller villages and the surrounding States, advancing them money and necessities; and some of the principal men seem to have a gathering round them of followers, who do whatever work is required of them simply for their food and an occasional present, and who seem to be regarded as the personal property of their master or owner. In the villages on the hills, bordering the south and south-east portion of the valley, we meet with Paloungs, living in long barrack-like buildings, separated into quarters for individual households. Little is known about these interesting people, who differ in speech, and claim to differ in origin from all their neighbours. They come from the neighbouring State of Taunbain, known to the Burmese as the La-pet Toung, or Tea Mountain, and they have introduced the tea shrub into the valley, growing it in a semi-wild state along the hill-sides. The plant shows no signs of pruning; at certain seasons of the year the young leaves are picked, placed in baskets, and steamed for a few minutes over vessels of boiling water, then dried in the sun, crushed together by hand, and considered ready for consumption. Further along the valley we meet with Katheys, from Manipuri, descendants of some of the older slave-gangs; they have lost both their Hindoo religion and language, but preserve traces of their origin, and appear to have kept to a considerable extent from intermarriage with the surrounding races. On the other side of the valley there are small communities of Leesaws, who are said to be descended from the original inhabitants of China. These people are certainly the lowest in the scale of civilisation of the races met with in the district, living in filthy huts, and confining themselves to the cultivation of pigs and sweet potatoes. Separate villages are found also inhabited by pure Chinese, though of a very low type, who appear to be distillers of spirits, keepers of gambling houses, and purveyors of opium. Mahommedan Chinese, or Pantheys, are also found as temporary residents in the district.

These Panthey Chinese are descendants of the Mahommedan immigrants from the west, who for several centuries enjoyed great power in China, and finally rebelled against the oppression of the central government, and formed an independent kingdom in Yunnan, which was visited and described by Dr. Anderson, when attached to Sir Edward Sladen's mission in 1868. Their power was, however, broken in 1872-73, when the Chinese reconquered the country, and are said to have slaughtered over 60,000 of the Mahommedan inhabitants. These Pantheys are easily distinguishable from their neighbours by their longer features and better physique; they are

keen traders, honourable in their dealings, and to be relied upon. The chief of the very large Panthey community that has settled in Burma accompanied me on one of my visits to the mines, and his intelligence and good nature caused him to be a most agreeable and useful companion.

To see all these race varieties at their best, one must visit the fair, or market, that is held every fifth day on the plains in front of Mogok, and which is attended by all classes. The miners leave their work, don their best clothes, and come to buy their provisions and luxuries for the next few days; their employers are busily engaged bartering for timber and tools and other mining necessaries. The villagers from the surrounding hamlets bring down their rice, tea, vegetables, pigs, fowls, or whatever commodity they have for sale. Pantheys and local merchants display their various wares, Manchester goods, tinned provisions, matches, &c., in temporarily erected booths, while at the corner of each lane, a Chinaman erects his stall of edible delicacies, which seem to be greatly appreciated by the simple villagers.

Blacksmiths from the neighbouring States ply their trade, and woodcutters bring in timber for houses or mines. In the fields, round this busy mass of humanity, which must often number 2,000 or 3,000 people, the ponies and pack bullocks graze, resting before returning with their owners to their homes laden with purchases or with the returns from their ventures.

We have heard in England a good deal about the natural rights of the inhabitants of this district, and the Government has caused a careful and searching inquiry to be made, both on the spot and at Mandalay, with regard to this question, the result of which proves that the mines were always, as they are now, Crown property. The inhabitants, however, from their close connection with the mines, have a moral right to every consideration, which the Government has recognised, and they are to be maintained in their old working by a system of license, for which they will pay a royalty or duty on the products they raise.

The labour that will be employed, with machinery, to work the various extensive tracts of the district, which, through physical difficulties, the natives have never been able to touch, will be recruited from the Chinese Shan States of Santa and Hotha, whose inhabitants are to be found in numbers all along the upper reaches of the Irrawaddi and throughout the Shan States. They are an active, sturdy-limbed, peaceable tribe, amalgamating well both with the Burmese and Shans, by whom they have been for centuries engaged as cultivators, miners, timber cutters, and, in fact, doers of all hard work which is distasteful to their employers.

Though this district is always known as the ruby mines, it must not be imagined that rubies are the only precious stones found in it, for the same mines produce red, pink, and blue spinels, sapphires of very fine quality and of nearly every shade of colour, from the yellow or Oriental topaz to the green or Oriental emerald, zircons, moonstones, and tourmalines.

Before concluding this short account of the ruby mine district, mention must be made of the Sanitarium, placed on a plateau on the opposite slope of the mountains, forming the northern boundary of the valley. This sanitarium, called Bernard-Myo, after the first Chief Commissioner of Upper Burma, our distinguished chairman of to-night, is at an elevation of over 6,000 feet above sea-level, situated in a rolling plain containing stretches of cultivation, and here and there an abandoned mine. A good cart road is being constructed to it, branching off from the ruby mine road at Khabine; cantonments have been built, and from the reports received both from the officers in command of the British and native troops in the station, the climate is everything that could be wished, bright, clear days, with sharp frosts at night, in the winter months, and a moderate rainfall in summer, accompanied with very cool nights. All around magnificent views open out of the surrounding country, sometimes covered in the morning by the fleecy clouds floating below, but on a clear day extending over the plains, watered by the Schweli River to Bhamo, and the winding lake-like reaches of the Irrawaddi.

At present its inaccessibility from Mandalay is a drawback to the fever-stricken invalids of the plains, but that is a difficulty that can and will be shortly overcome; while to the Europeans in the feverish portions of the ruby mine tract, who can reach it by a short ride of a few miles, it is an inestimable boon.

I now conclude with the hope that I have been able to afford you some knowledge about the district which, owing to a curious freak of nature, may practically be called the ruby mines of the world.

DISCUSSION.

Sir George Birdwood, K.C.I.E., C.S.I., said:—I can in no way contribute to the development, or even the illustration, of the topics specially dealt with in Mr. Streeter's paper, but having been called upon to speak, I am glad to take the opportunity to acknowledge the pleasure and instruction which I, with everyone in the room, have listened to it. There was always a deep interest in what an expert has to say about rubies, diamonds, emeralds, sapphires, and the other precious stones, of all of which the ruby is by far the most fascinating, both from its comparative rarity and the mystery that for so long shrouded the place of its production. But now we have been told everything there was to tell of the situation and working of the mines of this glorious and incomparable gem, and that by the very man who has tracked it to its secret source. Also, by a happy conjuncture of circumstances, the chair on this occasion has been occupied by the distinguished official through whose agency the ruby mines of Burma were at last thrown open to English enterprise and science. We are therefore under the greatest obligation both to Sir Charles Bernard and to Mr. Streeter for the rare pleasure they have afforded us this evening—an evening which will long remain rubricated, if I may so express myself, in the memories of all present. Mr. Streeter has, I am sure, the warmest sympathies and good wishes of the members of this Society in the bold adventure on which, with the characteristic commercial courage of our race, he has embarked; and I most sincerely hope that the old proverbial observation may once more be proved true in his case—

"Fortes Fortuna adjuvat."

I have no observations of any practical sort to make on the paper; but, as showing the great part that has always been played by India in the commerce of the old world, it may be of interest to point out that corundum, of which the ruby, sapphire, and topaz are mere varieties, derives its name from the Sanskrit *karu-vinda*, an old Indian name for the ruby; and that in the Mahratta country, the common corundum is called by the natives *korunda*. When the ruby first appeared in commerce has not been determined, but it was probably not earlier than the 7th century B.C. We know that the diamond did not reach the west before the 4th century B.C. In the English translation of the Bible the word "rubies" is found in certain passages in the Book of Job, and in the Book of Proverbs, but we do not positively know what substance is meant by the original Hebrew word here used, while the strong probability is that red coral is really indicated. The passage in Job (xxviii. 18) should, I believe, be correctly read:—"The dredging up of wisdom is more difficult than that of coral." The classical passage in the Book of Proverbs would, similarly amended, read:—"A virtuous woman who can find? For her price is far above red coral;"—a most precious substance in early antiquity. In Isaiah liv. 12, and Ezekiel xxvii. 16, the Hebrew words translated rubies probably signify carbuncles, but may quite possibly mean true rubies. It is truly wonderful to consider that the great motive power in starting the trade between the countries of the Indian Ocean, and the countries of the Mediterranean Sea, that is the immemorial trade between the East and the West, was supplied by the rubies, diamonds, emeralds, sapphires, topazes, amethysts, and other precious stones of India and Ceylon, and Further India; the whole mass of which ever produced would barely fill a single museum cabinet case. Now the exports from the East are cotton, wheat, jute, and the like raw materials of manufacture; in mediæval times they were chiefly spices; but in the furthest antiquity almost conclusively precious stones. The love, indeed, of these wonderful works of Creation is part and parcel of our common human nature, and in the infancy of civilisation it was confirmed by the highest religious associations; for not simply for ornament were first crystal, jasper, agate, coral, and other semi-precious substances, and later the true "precious stones" of the East, worn throughout antiquity, but as talismanic symbols of the seven planets and twelve signs of the zodiac, supposed to preside over the destinies of men. And in truth the score or two of famous rubies, diamonds, and sapphires that from century to century have excited the cupidity of conquerors do give a unity to the history of the world, binding together, by the associations connecting them, all men and all periods, like the stars, which have seen all things from the beginning, and will see all things to the end of time.

Mr. W. Martin Wood said this paper formed a complement to the one read two or three years ago by Mr. Scott on Burma proper, and the two together gave a complete account of the whole of that large tract of country. The portions relating to the peculiarly diverse races in the north-east corner afforded a fine field for the ethnologist. His attention had been particularly attracted by the Panthays of Yunan, who had been formed into a State, rose to their culminating point, and were destroyed within living memory. They were so far civilised and brought into political relations, that two or three of their number came to this country as a sort of deputation, and in their absence their State was destroyed and the people almost swept away. The great slaughter which then took place was mentioned in the paper, but he would aak whether the only remnants left were those in Northern Burma? There was no doubt that precious stones formed a great incentive to enterprise and research. But little mention had been made of the circumstances under which these treasures had become available to Mr. Streeter's firm. But the Chairman was fully aware of these circumstances, and he could not but feel that they were looking on rather at the celebration of a very successful loot on a grand scale.

However, that was over, and we must make the best of it. Mr. Streeter had referred to local miners' rights, but he would ask whether they were equivalent to the payment of wages and subsistence, and not much more. Probably it was correct to say that these mines were entirely public property, for there could hardly be any doubt about that from the way in which things were regarded in Burma, where it had always been the custom to regard all valuable products of the country as the property of the king. The paper, illustrated as it had been by the noble map and the photographic views, must have been highly appreciated by all present.

Mr. F. W. RUDLER congratulated the author on his extremely interesting communication, which was all the more valuable as coming from one whose knowledge of the subject was obtained at first hand. Up to the time of the annexation of Upper Burma, our knowledge of the geological conditions under which these valuable gems occurred was singularly meagre. Even so late as the time of the Indian and Colonial Exhibition, so little was known of this matter that a very high authority on mineralogy stated publicly that, according to the last accounts from Burma, there were probably no rubies there at all, that they were simply spinels. In a short time, however, that ignorance was dispelled, mainly by the exertions of Messrs. Streeter and Mr. Barrington Brown, whose report was no doubt familiar to everyone who took an interest in the subject. From time to time the speaker had had the privilege of examining the specimens sent home by Mr. Streeter, and could therefore speak with some authority as to their great interest. He had been especially struck with the specimens of calc spar, a crystalline form of carbonate of lime, with crystals of ruby embedded in it, an occurrence previously unknown to mineralogists, and it would seem as if there the primitive matrix of the ruby had been discovered. Mr. Streeter had spoken of the crude method in which these deposits of ruby-bearing limestone were attacked by blasting and by breaking the pieces in such rude fashion that considerable injury resulted to the gems. With modern appliances, however, the rubies ought to be easily separated from the enclosing stone, the limestone being very soft, whilst corundum was extremely hard. Limestone, again, was readily attacked by weak acids, whilst corundum was practically unattacked by ordinary reagents, and, therefore, either mechanically or chemically, the separation ought to be easily effected. However, it was not so much in the direction of blasting the limestone that he should look for the development of the mines, but rather to the working of what were called the *ludwins*—the limestone caves—in which nature had in the course of ages dissolved away the limestone, leaving the impure residuum in which the rubies were embedded to the extent, in some cases, of 25 per cent. There could be little doubt that the origin of the ruby-bearing clay, or loam, was very similar to that of the red cave earth commonly found in out limestone caverns. The limestone was attacked by water; every shower carried with it carbonic acid, every stream took up the various products of vegetable decomposition, and thus charged with humic acid and carbonic acid, the water filtering through the cracks and crannies of the limestone would necessarily dissolve it away, but would not attack the various insoluble matters which were commonly present, and which were left behind as a solid residuum. That this was really the origin of the ruby-bearing clay in the *ludwins* was proved by the presence of choke-damp, which must arise from the evolution of carbonic acid. This seemed to be a serious embarrassment to the primitive miners, but with modern appliances ventilation could easily be effected. The gravels consisting of the mechanically disintegrated gneissose rocks, though no doubt very valuable, would probably not be so rich as the cave earth. It had been said that if so many rubies were produced the value would fall, but he doubted if that would occur to any appreciable extent for a long time. They had had experience in the case of the South African diamond fields how readily a large output of precious stones could be absorbed. He looked forward, therefore, to the most brilliant results for this enterprise, and thought they might regard Mr. Streeter and his father as the pioneers of quite a new industry.

The CHAIRMAN said he thought all present must have enjoyed very much listening to this paper, and the discussion, and Mr. Rudler's remarks on the prospects of the *concessionaires* were certainly very cheering. Few of them probably could understand the intense interest which a man like Mr. Streeter took in these rubies, and the working of them, not only from the point of view of the company to which he belonged, of which he hoped he would be managing-director, but also from the scientific point of view. He had been very much impressed himself, when the party first went up, and telegrams were coming down, with the excitement there was, and when he heard of their arrival it was interesting to hear that the first thing that happened when the troops got up to the ruby-bearing plain, after a longish march, was that the British soldiers, instead of taking a rest and breakfast, all threw themselves on the hill-side and began digging down in search of rubies. Not only that, but shortly afterwards, when that great soldier, Sir Frederick Roberts, went up, he and the whole of his staff set to work to find rubies like those which Mr. Streeter had placed on the table. There was the greatest interest in the ruby business amongst all who had been there, and who wished every success to the *concessionaires*. It had been said that at the time of the Colonial Exhibition one of the highest authorities on Indian geology said that after all it was not known whether there were any rubies at all in Burma. There was this substratum of truth for the statement, that when the expedition got up to Mandalay they

found no rubies among what had been called King Theebaw's regalia, and none were found among the people in the city. Even the native soldiers and others, who perhaps knew how to find things when they got into a conquered town, scarcely found any rubies. He only heard of one or two good ones, but he did hear of one magnificent ruby, a celebrated one belonging to King Theebaw, which had been looted by his own subjects at the time the army came up, and which, if they could have got it, would have been sent home to the Queen. Unfortunately, they were not able to get hold of it; those who had possession of it hearing that information of its existence had been received, made away with it. It was reputed to be worth many thousands of pounds, and to be the finest ruby the Burman kings had ever had. All big rubies had to be brought to the king, and the story was, that when the finder brought this ruby, the king asked him what he would have for it, and he said he should like to have a whole cart load of gold, which was given to him. That was the story about this particular stone, but when they got to Mandalay no one could find any. Since then the expedition went up to the ruby mining tract more than a year after Mandalay was taken, and there rubies had been discovered. As far as he had been able to find out, the value of the rubies sent from Rangoon in one year was generally about £80,000, which was exclusive of those sent across by land to China and Siam, and used in Burma. Rubies were always considered to be royal property, and in the treaties which the British made with the kings of Burma years ago such products as teak, rubies, earth oil, and rubber, were recognised as royal property, as they had from the earliest times of which there had been any record in Burma. They were so recognised now under British rule as royal or State properties. The largest revenue that King Theebaw or his successors ever got from the mine was about £20,000 a year, but under the present lease to Mr. Streeter and his friends the income would be about £40,000 a year, besides a share of the profits which would go to the Burman treasury. It was not all quite plain sailing before the *concessionaires*, or before those who went to purchase rubies in Burma. When Mr. Streeter was staying with him in Mandalay, two or three years ago, he was much struck with the story he told him about a Shan gentleman, who had small parcels of rubies which he took to London and sold. Some came to the hands of Messrs. Streeter, and young Mr. Streeter, feeling curious to know what the Shan gentleman did with the money, and how he occupied his time in England, had a note taken of his movements. He found the very first thing the Shan did with the money produced by these rubies was to go off to Birmingham, and lay out a considerable share of it in a large parcel of glass stones to take out to Siam and Burma, wherewith he might salt the mines there. Mr. Streeter was much interested when he went up to the ruby mines to find what he thought he recognised as some of these identical stones. They were not brought to him to buy, because the people thought probably that he would know better, but they were offered to British soldiers and officers as valuable stones. These gentlemen not unnaturally brought them to Mr. Streeter for his advice before purchasing, when he recognised the stones as his old friends produced in Birmingham. Mr. Martin Wood had asked one or two questions about the rights of the native miners, aud suggested that perhaps those rights would be confined to being allowed to work for such wages as they could get; but that was not quite the full extent of their rights. The regulations passed by the Legislature provided that all residents in the ruby country who wished to mine were entitled to a licence to do so; those who already had mining claims were allowed to go on working them; and those who had more extensive kinds of mining claims were also entitled, when they were worked out, to receive from the Government a right to mine in another parcel of land in the district; so that the full rights of the residents—as far as any of the officers interested in them, and who had been making inquiries, could tell —would be preserved. He believed these miners would be very much better off under the present *régime* than the past; for although King Theebaw got a very small revenue from the mines, it did not at all follow that a very small sum was realised from the miners. Not only had they to pay royalty on the stones raised, and to render as royal property every stone worth more than 2,000 rupees, but they had to pay taxes on their houses and on everything they had; and heavy licences were levied from the miners and people who sold in the bazaar, which now was quite free. Not only that, but the miners were expected to take from the lessees advances of money to work their claims, and the least interest he had heard of was 12 per cent. per mensem, so that they had to pay in the old days a great deal more than they would under the present *régime*, which was only the royalty of 30 per cent. on their own valuation of the stones they might raise. They were at liberty either to pay that 30 per cent. on their own valuation, or to sell the stones to Mr. Streeter's company at that valuation, so that either way they would only have to pay 30 per cent. on the stones they raised. It had been suggested that they were rather in the dark as to the circumstances under which the concession was given to Mr. Streeter. The facts were that he and his friends went out first of all and investigated the mines, and it was in consequence of those investigations, and of Mr. Barrington Brown's, that people in England knew anything certain about the mines at all. At one time there was a concession proposed out there, but eventually tenders were invited in England, on certain terms, for a lease of the Government rights in the mines for seven years. Certain tenders were received, and Mr. Streeter's was approved by the authorities, and consequently he had the lease, which would begin to run from November

next, by which time he would have his machinery *in situ*, and be able, he hoped, to commence work. Mr. Rudler had pointed out that probably the cave mines would pay the best, but he understood that Mr. Streeter and his friends thought perhaps the most paying branches would at the outset be the dredging of the rich red gravels from the bottoms of the streams, which the natives with their rude appliances had never been able to get at. He had been glad to hear more than one speaker express his interest in the concession, and hoped it would become valuable to the *concessionaires*, He thought the Government were quite wise not to attempt to work the mines themselves, but to give them to experts who would work them according to the most recent knowledge, and be able to bring the rubies into the market to the best advantage. When he was in Burma, a proposal came to him with some authority that the Government should undertake the work; but he submitted that British officers had a great deal to do in trying to quiet the country and introduce order, that they had not the requisite knowledge and time to become ruby miners, and that it would be very much better, and more in consonance with English ways in other parts of the world, if a concession were made over to the approved firm, and he was glad to say that this method had been carried out. He concluded by proposing a vote of thanks to Mr. Streeter.

The motion having been carried unanimously, Mr. Streeter briefly acknowledged the same, and the proceedings terminated.

APPLIED ART SECTION.

Tuesday, February 5, 1889; General DONNELLY, C.B., in the chair.

Mr. J. STARKIE GARDNER said that, before reading Mr. Garnier's paper, it might be well, for the benefit of those unacquainted with the subject, to preface it with a few introductory remarks. Porcelain is a kind of pottery readily distinguished by its translucency, owing to its having become more highly vitrified, or more like glass. Its discovery in China seems to date from the beginning of our era, and it first passed westward, long afterwards by the caravan routes of Central Asia. The Persians, who were long previously most expert potters, never rested or resigned themselves to be excelled by the Chinese, and after many attempts succeeded in producing a translucent pottery of their own, but wholly different in composition. The Japanese also successfully produced porcelain in 1513. The Chinese porcelain continued to penetrate westward, and at last reached Europe, where it excited unbounded admiration. Its translucency, exquisite surface, and musical ring, contrasted with even the best faïence that could be produced in Italy, were so astonishing as to be regarded as little short of miraculous, and to be producible only by aid of magic. It is small wonder, that in that period of activity, called the Renaissance, repeated efforts were made to discover the secret, which were mostly futile, because they assumed the manufacture to be extraordinarily difficult and occult, instead of very simple. The Venetians, whose city was the great emporium of the East, succeeded first in making something akin to it, but no specimens exist, and their rivals, the Florentines, produced a fair quality, under the Medici, in 1575-80. Next the French discovered a species of porcelain in 1673, and soon after the Germans were producing the famous Meissen or Dresden china from true kaolin. Last in the race, our own country did not make any kind of porcelain till nearly the middle of the 18th century, when the factories at Bow and Chelsea were set up, to be followed shortly by others, notably those of Worcester and Derby.

The paper read was—

MANUFACTURE OF SEVRES PORCELAIN.

By EDOUARD GARNIER.

I.—ITS ORIGIN.

In 1698, Martin Lister, an English doctor, who accompanied the Duke of Portland, ambassador plenipotentiary to France to negotiate the Treaty of Peace of Ryswick, and who employed the six months of his stay in Paris in visiting the savants and the libraries, and in seeing everything of interest and curiosity in the capital and its environs, speaks thus of the manufactory of St. Cloud in his little book entitled, "A Journey to Paris in the year 1698."

"I saw the pottery of St. Cloud, with which I was marvellously well pleased, for I must confess I could not distinguish betwixt the pots made there and the finest China ware I ever saw. It will, I know, be easily granted me that the paintings may be better designed and finished (as indeed it was), as our men are far better masters in that art than the Chinese; but the glazing came not in the least behind their's, not for whiteness nor the smoothness of running without bubbles . . . . . which I account part of the felicity of the age to equal, if not surpass, the Chinese in their finest art."

These praises of the English doctor, which now seem to us exaggerated, are understood and excused when we think of the importance that had been attached, for two centuries at least, in Europe to the search for a pottery to imitate Chinese porcelain, around which manufacture the public had weaved fantastic

legends. Even as late as the 17th century marvellous properties were attributed to it, among others, that of breaking as soon as poison was poured into it.

The discovery of the manufacture of porcelain, made about 1690, by a potter of Rouen, Louis Poterat, "Le Sieur de St. Etienne," whose little-known name deserves to be inscribed in the golden book of ceramic industry by the side of Bernard Palissy and Josiah Wedgwood. His discovery constitutes an immense advance, and it marks one of the most important steps in the history of earthenware. It is the more remarkable since the porcelain of Rouen, the manufacture of which, was soon transported to St. Cloud, where Martin Lister saw it in full activity, was not at all of the same nature as the Chinese porcelain.

There are, in fact, two kinds of porcelain—kaolinic porcelain, or hard porcelain, of exclusively Oriental origin, the paste of which is almost entirely composed of kaolin, that is, of that white clay which is found in its natural state in the bosom of the earth, and which has only to be submitted (as have all clays employed in ceramics) to the operations of crushing, washing, &c.; and artificial or soft porcelain, known for a long time by the name of French porcelain, the paste of which, being of a very complicated composition, varied according to the manufactories. The constituent elements were always based on salts, soda, and silicon. These were mixed so as to form a vitreous paste, which was crushed, and given a body by mixing with chalk and a calcareous marl. Soft soap and size then communicated to it the tenacity and plasticity necessary to shape it. For the composition of this porcelain more research and labour were necessary than in kaolin porcelain, which is composed of natural products.

The porcelain industry did not, however, at the beginning develop as might have been expected from a discovery so long looked for. Whether it was the want of initiative, of artistic taste, or of commercial discretion in the directors of the manufactory at St. Cloud, where the first workshops were installed, or whether the new matter, on account of its want of plasticity, did not admit of its being easily fashioned into varied shapes, the manufacture remained for a long time stationary, and the porcelain which had excited so much admiration from Lister is hardly known except for some bowls, jardinières, water-pots, and vases, and especially some of those charming little salt-cellars, the bottoms of which are always ornamented with flower sprays of a very peculiar character. These porcelains, the paste of which was a beautiful milky white, of a soft and warm look, are generally ornamented—and sometimes most delicately—with ornaments in blue *camaïeu*; sometimes, but very rarely, the ornamentation is of a pseudo-Chinese style, in colours heightened with a little gold. On some pieces it is in white relief. All bear as a mark the sun of Louis XIV., and later the initials of the name of the town below those of the maker, Henri Trou.

However well kept was the secret of the composition of this new product, it leaked out, and rival manufactories soon arose, first at Lille, in 1711; then at Chantilly, in 1725, under the patronage of Louis Henri, Prince Condé; and a third at Mennecy, in the domain of the Duke of Villeroy, who protected it. But these manufactories, in spite of the perfection and the care brought to the manufacture, could only produce pieces of relatively little importance, ornamented sometimes with much tact and taste, but which in reality offer nothing remarkable.

This sort of inferiority, which proceeded especially, as we have just said, from the nature of the paste and its want of plasticity, became more noticeable when the porcelains of Saxony began to penetrate into France. While the manufacture of porcelain in France was progressing very slowly, a considerable event had happened in Germany, where Boettger had found with the kaolin discovered at Aue, in 1709, the means of making true porcelain. The manufacture established under his direction by the care of the Elector of Saxony at Albrechtsburg and at Meissen, had rapidly developed, and Dresden porcelain soon became so much the fashion in Europe that France, which until then had occupied the first position in everything that related to art industries was forced to give place before the incontestible superiority of Meissen.

II.—Manufacture at Vincennes.

The court of Louis XV. was uneasy at this state of comparative inferiority, and it was understood that serious efforts must be made to remedy it as soon as possible.

Thus, when two fugitives from the manufactory of Chantilly, the brothers Dubois, about 1740, proposed to the Marquis Orry de Fulvy, brother of the Comptroller-General of Finance, to disclose the secret of the manufacture of porcelain, they found him disposed to receive

their proposals with attention, the more so as he was certain to receive from Louis XV. the necessary privileges to assist in commencing a manufacture which would free France from the tribute paid to Germany. The brothers Dubois had worked in the manufactory of St. Cloud, then at that of Chantilly, from whence they had been expelled for misconduct. But at that time people were so bent on the manufacture of porcelain, and the fine and modish productions which Saxony sent into France were so sought after, and enjoyed so great a demand, that the proposals of these men were received with enthusiasm, and no inquiries made about their past. Thanks to the support of his brother, Orry de Fulvy was able to put at the disposal of his two assistants the riding school of the Chateau de Vincennes, which had been abandoned for some time, and granted them besides a lodging in the superintendent's residence.

Unfortunately for the noble protector, the brothers Dubois had to leave Vincennes after four years of fruitless and expensive trials, the want of success of which were due as much to incapacity and ignorance as to misconduct. They had swallowed up, not only all the money which Orry de Fulvy had put at their disposal, but also the sum of 10,000 livres which the king had granted to encourage the new undertaking. The business was about to be completely abandoned, when a workman named Gravant, a loyal, intelligent, and devoted man, who had been employed by the brothers Dubois, and who had watched their trials attentively, proposed to Monsieur de Fulvy to continue them a short time longer. He soon proved that the confidence which he knew how to inspire had been well placed, and even in 1745 he could show specimens of manufacture so perfect that the future seemed assured.

It was then that Orry de Fulvy, supported by his brother, formed a society whose founders were almost all interested in its success, and whose capital was fixed at 90,000 livres, divided into twenty-one parts. The capital was successively increased and brought up to 250,000 livres.

A decree of the Council, dated July 24th, 1745, acknowledged the society, and fixed for twenty years the exceptional privileges which were granted to it. The new manufactory had then everything that was necessary for its prosperity, but it was constantly in financial difficulties, and very often Louis XV. had to come to its assistance by providing considerable sums of money. We should say, in fact, that Orry de Fulvy, who had created the manufacture, and who had had the direction of it, did not appear to have been a very skilful administrator, nor was he apt to impress his individuality upon the works carried out by his orders. A period of experiment ensued, which was prejudicial to the establishment, characterised by that want of originality which is to be remarked in the first porcelains manufactured there.

In the chief place, the manufactory strove to emulate German porcelains, and without servilely copying the forms and the models of Meissen, imitated the ornamentation in relief, though with a more discreet taste and a finer decorative feeling.

As in Saxony, charming little vases were ornamented with flowers modelled and painted from nature, and these, which had a great success at first, led to the manufacture of flowers in relief, destined to ornament the inlays, the lustres, and the girandoles which began to establish the reputation of the manufacture.

During the first years, however, the sale was insignificant; in 1750 it only amounted to 32,696 livres, of which 26,323 livres were for flowers; and the German porcelains, whose price was less, continued to be imported into France in considerable quantities; in this respect the new undertaking did not fulfil either the aim which its founders proposed, nor the hopes which had been conceived in high places. In the financial point of view it was a failure; the money which those interested in it had put into the business, the large sums which the king had advanced—more than 100,000 livres in three years—was all swallowed up, and the deficiency was increasing year by year. It was then understood that another course must be followed, and that success could only be obtained on the condition of a great effort being made.

In accordance with the advice of J. B. de Machault, Count d'Arnouville—who had succeeded Philibert Orry in the post of Comptroller-General of Finance—and of Madame de Pompadour, whose enlightened intelligence then protected art and industry so efficiently, Louis XV. took the manufactory under his patronage, renewed for twenty years the privileges which he had granted, and advanced fresh sums of money. The Director of the Academy des Sciences, the learned Hellot, was charged with the superintendence of every-

thing which related to the manufacture, more especially with that which concerned the pastes, the colours, and the firing. The Court goldsmith, Duplessis, an ingenious and fertile artist, was to furnish designs and shapes, and to give all his care to the perfect execution of the pieces. The painting and gilding were under the direction of Mathieu, enamel painter, who was not wanting in talent, but who, however, was soon replaced by Bachelier, a man of initiative, taste, and knowledge, whose happy influence was brought to bear on all the industrial arts of this period, and to whom Vincennes and Sèvres owed certainly the most perfect works that came from their furnaces.

In 1751, the death of the principal partner, Orry de Fulvy, by necessitating the repayment of his capital to his heirs, shortened the life of the company. A second decree of the Council, given April 19th, 1753, reorganised the company on another basis, and limited to twelve years the new privilege granted in the name of Eloy Brichard. The progress of every kind which the manufacture had made since its installation decided the king to interest himself to the extent of a third share in its working, and to declare himself, definitely, its protector. He authorised it to take the title of *Manufacture royale des Porcelaines de France*, and to mark henceforth with his monogram the pieces there manufactured.

The ground at Vincennes became insufficient in consequence of the considerable development of the manufactory, and the company, moved also by the desire of bringing the manufactory near the dwelling of the king, soon sought a new settlement. Sèvres was chosen, as its situation between Paris and Versailles answered the end proposed, and, in 1756, the manufactory was solemnly installed there, in buildings constructed on a piece of land where formerly had been a little chateau belonging to the musician Lulli. Of this a wing still remains. The name of the old and first factory was quickly dropped, and then as now, Sèvres alone was known; but it is none the less true that it was at Vincennes that were made, from 1748 to 1756, those beautiful pieces of soft porcelain which established over all Europe the fame of the porcelain of France. The collections of her Majesty the Queen, at Buckingham Palace and at Windsor Castle, as well as those of Sir Richard Wallace, at Hertford-house, contain numerous and remarkable specimens of this period which will ever remain the most perfect witnesses of the art—so decorative, so gracious, and so distinguished—of the end of the reign of Louis XV. Never has the famous Sèvres blue, or *bleu de Roi*, attained a brilliancy, a purity, and a depth comparable to it; never have the golds been more solid and more lustrous, making by contrast the paste more delicately creamy-white. At this time Hellot found the beautiful rose, which gave such fresh and dazzling grounds, and the secret of which seems to have been lost with him, or with the workman who prepared it under his direction; for in spite of the admiration it excited, and the great success obtained, we do not find a single piece bearing a date later than 1760. It is the rose which, according to the rather fantastic designation of an amateur, or of a merchant of an active imagination, has been called for a long time, especially in England, the "Rose Du Barry," although the greater part of the pieces thus ornamented belong to a date before Madame Du Barry was born.

To the same epoch, and also to Hellot, we owe the turquoise blue, soft in tone and harmonious even when placed on a smooth surface, but on which, in the least relief, the light scintillates and is reflected like the sparkle of precious stones.

III.—Manufactory of Sevres.

According to the articles of the new company, the capital had been raised to 240,000 livres, divided into eighty shares of 3,000 livres each, of which a third, as we have said, belonged to Louis XV. The secret of the manufacture of the pastes and of the colours on which the undertaking hinged, became, with the consent of all the members, also the exclusive property of the king, who reserved the knowledge of it for his agents alone. There was chosen as director an intelligent and upright man, Boileau, whose administration was controlled by a commissioner named for this purpose, and there was added to the artistic staff, Falconet, sculptor to the king, who took the chief direction of works of sculpture, and Genest, a painter of talent, who was named chief of the painters, under the direction of Bachelier. The famous Boucher and Vanloo furnished sketches for the painting of cartels, and drawings for the figures and groups, which were modelled by skilful sculptors, and executed in biscuit. The establishment then made such progress,

and the manufacture arrived at so high a degree of perfection, that France, which in 1745 was obliged to draw from Germany all its fine porcelain, found in less than fifteen years the perfection of the products of the royal manufactory such, that it not only had the rignt to prefer its own porcelain to all other, but could send it with pride to foreign nations, by whom it was sought for with eagerness. In the years 1756 and 1758 the sales amounted to 210,000 and 274,000 livres. In spite of this prosperous state, in the year 1759 a dispute arose between the Royal commissioner and the company, the results of which brought

Ed. GARNIER del. TRICHON Sculp.

BOAT-SHAPED VASE FROM THE ROYAL COLLECTION, WINDSOR.

about the dissolution of the society. Little satisfied, rightly or wrongly, with the financial results of the business, the shareholders wished to obtain from the king new concessions; but in consequence of the inquiry which was made on this occasion, their complaints seemed to have so slender a foundation, that the minister gave no consideration to them, in spite of the threat they made of retiring. On the contrary, it was the king who, on the advice of his council, ordered them to be paid their shares, and by this act became sole proprietor of the manufactory, which received an annual subvention of 96,000 livres, payable monthly by

the royal treasury; and kept Boileau, who had so well directed it hitherto, at the head.

At this time, the manufacture consisted entirely of artificial or soft porcelain, unrivalled if we regard it from the artistic point of view alone, but of an indifferent quality for domestic use, and unable to sustain comparison, in this respect, with the hard porcelains brought from China, or which came from Germany. Thus the manufactory, which had for its mission to crush all foreign competition, accepted with eagerness the proposals of two German workmen, Busch and Stadelmeyer, who offered to reveal the secret of the Saxon porcelain, but they had to be dismissed after several trials, more or less satisfactory, on which were spent not less than 26,000 livres. Their process relied exclusively on the use of material which had not yet come into France, and which would have to be imported at great expense from abroad. The same cause, some years later, induced the directors to reject the offers of Hannong, who possessed the secret of the processes used by his father in his manufactories of Strasburg, and Frankenthal.

However, many savants, among others, Macquer, who had been connected as chemist with the manufactory since the resignation of Hellot, were persuaded that kaolin ought to be found in France as well as in Germany, where many beds had been discovered. Their predictions were fulfilled, and by a letter dated April 26th, 1760, a doctor of Alençon, Odolant Desnos, told Macquer that this precious substance was to be found in quarries situated not far from that town; unfortunately, this kaolin was of an inferior quality, and the trials made with it—of which there is a specimen in the museum of Sèvres—only gave a grey porcelain, too rough to compete with the German productions.

Macquer was not discouraged, and caused searches to be continued; but it was only in 1768 that he was able to find the magnificent beds of kaolin at St. Yrieix, near Limoges, the chance discovery of which was due to the wife of a poor country surgeon named Darnet, and of which the first specimens had been sent to Macquer by the Archbishop of Bordeaux. The manufactory had at length attained the end of its highest ambition, but its skilful administrator, Boileau, who had directed it with so much intelligence, could not benefit by this discovery, as he died in 1773, leaving 300,000 livres in coin, and an equal amount in porcelain, in book debts, and stores of all kinds. All of this was unfortunately dissipated in less than six years by useless expenses, and especially by the unworthy management of his successor, Parent, who had to be prosecuted, as well as the cashier of the manufactory, and sent to prison. By a decree, dated December 20th, 1778, the king named as director, Régnier, who had occupied the post of sub-director, and whose capacity, and especially whose integrity, were well known to all. It was under his skilful direction that the first works were undertaken of importance in hard porcelain, and especially the large and magnificent vases of which the Louvre possesses one of the most remarkable specimens. It is also from this time that date the first applications on soft porcelain, of enamels in relief associated with chased ornaments on gold plaques, a true jeweller's work, which has caused to be given to porcelain thus decorated the name of "Jewelled Sèvres."

In the beginning of 1789, the manufactory of Sèvres had no rival; its well-deserved renown excited admiration in all Europe, and foreign sovereigns disputed with each other for its productions. But soon the cancelling of the privilege under the protection of which it had grown and prospered, as well as the commercial competition of the national industry, now freed from the obstacles which until then had obstructed its path, rendered the position of the manufactory critical. Its existence was threatened so much the more seriously, in that the financial embarrassments of the treasury did not permit any more sacrifice to be made for it; and it became at the same time impossible for its agents to collect the money due to it on all sides.

These difficulties grew worse, and rose to such a point that it was a question in 1790 of selling the manufactory to pay the debts, and to lessen by so much the charges on the crown. But on the report which the director of royal buildings made, representing to the king that, in the critical circumstances in which they were placed, the sale would be disadvantageous, and that, besides, it would be impossible to realise the amount, Louis XVI. decided to preserve it, but on condition that expenses were reduced so that not more than 300,000 livres were spent annually.

The National Assembly, on its part, judged that the manufactory of Sèvres, like that of Gobelins, ought not to be confounded and alienated with the goods called national, and by its decree of the 26th of May, 1791, it included them in the domains left at the dis-

posal of the king and at the charge of his civil list.

After the fall of the monarchy, the Convention, on the report of the Minister, Roland, decided that the manufactory, being one of the glories of France, should be preserved as a national establishment, and placed under the supervision of *Agriculture et Beaux Arts* in the Ministère de l'Intérieur. But for some years the emptiness of its treasury was such that the administration, finding it impossible to make even the smallest payments to those of the artists and workmen which it had kept, was obliged, in order to save them from dying of hunger, to solicit the Government to distribute grain, meat, and necessaries from the State magazine, as well as to authorise a lottery of a certain number of porcelains which were in stock, in order to procure a little money. By a decree dated 13th Pluviose, year III. (February 1, 1795), the administration of the manufactory, which, during the worst days of the Revolution had been usurped, so to speak, by a workman named Chanon, was confided to three administrators—Hettlinger, who fulfilled the functions of inspector since 1785; Salmon the elder, the keeper-general; and François Meyer, chemist, who gave in his resignation a few weeks after his nomination, and whose place was not filled up. Hettlinger and Salmon remained at their functions until the 25th Floreal, year VIII. (May 14th, 1800), the time when the learned chemist, Alexandre Brongniart, was called to succeed them. A firm and enlightened administrator, he began by making numerous reforms rendered necessary by the precarious situation in which he found the establishment of which he had been given the direction, and he afforded a rare example of disinterestedness in proposing to reduce his own salary from six thousand francs to three thousand; he thus succeeded in sustaining the manufactory with the resources which it drew from the product of his sales alone until the day when, in 1804, it was again joined to the domain of the Crown and administered on account of the emperor, who provided for its wants by means of annual budgets.

But dating from the day when Brongniart took the direction of the manufactory, the fabrication of soft porcelain was completely abandoned to be replaced entirely by that of hard porcelain. The whole period, which extends from the foundation of the royal establishment until this epoch, constitutes a quite distinct phase in the history of the manufacture, and before going farther, it will be interesting to consider its productions, and especially to note the influence which it exercised on the development of the industry of porcelain in France and abroad.

Thus, as we have said before, it was at Vincennes that were made the most beautiful pieces of soft porcelain *(paté tendre)*; those which established over the whole of Europe the fame of the French porcelain, as it was then called. But from the time that Louis XV. took over the manufacture on his own account, the Intendants of the Royal Household, who were charged with its administration, and the directors, who had a sufficiently high commission on the sales, sought by all means possible, first from zeal and then from interest, to cause the new establishment to prosper, from the commercial much more than the artistic point of view. The scientific researches which had formerly led to the discovery of the beautiful colours noticed were discontinued; they limited themselves to the models already in use, and to tracing garlands and festoons of pearls of enamel with spangles of gold, and little raised medallions framed in delicately chased and engraved gold, and fixed on the body by means of colourless glaze. It was, indeed, a true jeweller's work, fine and delicate, and the perfection to which works ornamented by this process were brought, showed what new results the skilled artists of Sèvres might have achieved had they been properly directed. At Sèvres, new forms were less sought for than at Vincennes, and were only undertaken occasionally. The ancient models were revived; the manufacture of important pieces, and large vases of state, which the public did not buy because the price was too high, and which were reserved for presents to sovereigns and ambassadors, was discontinued. These were replaced by everything which was of an easy and daily sale; table services, tea sets, salvers, flower-pot holders, small vases, *pots pourris*, &c. All these porcelains, with some exceptions, were ornamented with an extreme skill, and bore the seal of distinction and elegance, although a little mannered, as was the case with most of the artistic and industrial productions of this time. An irresistible charm is lent to them by this marvellous soft paste, sweet and alluring to the eye, which will remain one of the most glorious discoveries of French industry. It was, however, at Sèvres, and not at Vincennes, that were executed the beautiful biscuits which contributed so much

to the reputation of the manufactory; the hunting trophies, after Oudy; the Bather and the Cupids of Falconet, and all those groups, busts, and statuettes for which Caffieri, Pajou, La Rue, Boizot, Clodion, and so many other celebrated artists furnished the models.

At the commencement of the manufacture, when it was a question of endowing France with a new industry, the manufacture required—and received—privileges, under the protection of which it increased and prospered, but of which the importance has been singularly exaggerated by most writers who have occupied themselves with this question. It was desired both that rival manufactures should not compete with it, and that the workmen which it employed should find themselves with sufficient emolument not to be tempted to carry abroad the secrets of the manufacture known to them.

A decree of the Council of State, dated April 19th, 1747, regulated in a sufficiently severe manner the obligations of workmen towards the manufactory. They might not absent themselves on any pretext without an authorisation signed by the director, and if they wished to leave the establishment it was necessary that they should give warning six months in advance. Even then they were not always granted the permission which they solicited, unless they pleaded the bad state of their health. On the other hand, they were exempt from military service, paid no taxes, and had the whole of their salary in case of illness; besides, those who were contented with modest apartments could have lodgings provided, two rooms and a cellar, which the manufactory placed at their disposal.

These precautions had especially as their object the preventing foreign manufactories, and especially that of Tournai, which had produced very beautiful soft porcelain, from tempting away the workmen of the royal manufactory. In this respect the rules were pitiless, and in 1752, a man named Varion, a turner, having fled in order to go to work at Tournai, the Guard of the Seals, and the Comptroller-General of Finance caused him to be rigorously pursued; and put in prison two of his comrades, turners, as he was, Gravant and Jean Desnoyer, accused and convicted of having conducted Varion to the conveyance by which he escaped. It was only in consideration of the services which his uncle, of whom we have spoken before, had rendered to the manufactory, and to the rather important position which he held, that Gravant was not sent to prison with his companions.

The French manufactories which existed then, and of which we spoke a few words in beginning—St. Cloud, Lille, Chantilly, and Mennecy—were not to be feared, but it was necessary to look after the future. The success of the royal establishment might induce manufacturers to create similar ones, and it was prudent to take prohibitive measures in consequence. A decree dated April 6th, 1748, confirming the exclusive privilege granted July 24th, 1745, for "the manufacture of porcelain after the manner of Saxony" prohibited the formation of any new porcelain establishments.

As late even as 1760, and when the four manufactories which I have cited could do no harm to the chief establishment, a decree was made which reserved to the royal establishment "the exclusive right of ornamenting porcelains with subjects either figures or flowers painted in varied colours, the application of gold; and the production of works in full relief.

For several years nothing came from without to trouble the quietude of the manufactory thus privileged, but this state of things could not last long.

In spite of the ditches and ramparts of Albrechtsburgh, in Meissen, in spite of the oath taken by the workmen, under the most terrible threats, to keep the secret of the manufacture until death, the secret did not fail to leak out. It became known that the famous porcelain of Saxony was made from a clay of a very particular kind, which was found in many spots on German territory, and before long numerous manufactories were founded abroad. An Alsatian porcelain maker, Hannong, established a manufactory at Strasbourg, but Sèvres took offence at it, and the unfortunate potter had to remove his works to Frankenthal in the Palatinate. This was the first and only victory which the manufactory gained over its rivals.

Some time later, when the mines of kaolin of St. Yrieix had been discovered and bought on account of the king, De La Borde, first *valet de chambre* to Louis XV., knowing the discovery which had just been made, formed a company with one of his friends, Hocquart de Courboi, and Hannong the younger. The last, as we have seen, had just been called to Sèvres where, after some attempts which were unsuccessful because it was impossible to bring the kaolin from Germany, the engagement

that Boileau had signed with him was cancelled. The three partners bought of a man named Borda, whose lands adjoined the royal quarry, considerable quantities of kaolin, and founded at Paris, in the Faubourg St. Denis, a manufactory, which was placed soon afterwards under the patronage of Monsieur the brother of Louis XVI.

The start had been given, and some years later Paris contained many manufactories of porcelain. But in order to elude the prescriptions of the decree of 1760, renewed February 15th, 1766, the crafty manufacturers followed the example of their fellows at the Faubourg St. Denis, and asked the members of the royal family, and Marie Antoinette herself, to take the new establishments under their protection. As everything which related to porcelain was then very fashionable, and as their vanity was flattered, the members of the royal family accepted the position, and there were soon, besides the manufactory of the king—that is to say, Sèvres—and that of Monsieur—which we have just mentioned—the manufacture of the queen, those of the Comte d'Artois, the Duc d'Orléans, the Duc d'Angoulême, &c.

Then began between the different manufactories and the directors of Sèvres a furious strife, in which the royal establishment had always the worst, and which reduced its famous privileges to a dead letter. Not only the manufacturers of Paris made porcelain, painted in all colours and gilt, but they also took away men from the Sèvres works, and managed even to copy their models and take imprints of their moulds. They offered the artists and workmen of Sèvres double and treble the wages paid to them by the royal manufactory, and those who were thus cajoled came on holidays to Sèvres and St. Cloud sumptuously dressed for men of their position, spending money with affectation, and boasting to their old comrades of having gained more in a month than they had earned before in six months at the manufactory.

The directors of Sèvres complained with good reason, and induced the Lieutenant of Police, Mons. de Lartines, to take coercive measures, but these were useless. They might have understood that those they strove against were the stronger.

In the first place, they met with a systematic opposition on the part of the Minister, Bertin, a man of broad and enlightened mind, who did not understand why, if men were permitted to paint flowers on porcelain, they were forbidden to paint them in the colours which nature had given them. Besides, it was very difficult, not to say impossible, for a Minister to resist a demand addressed by a prince of the blood or by one of the king's courtiers.

It was thus that the Count of Provence, afterwards Louis XVIII., having ordered for his personal use one of the richest services at the manufactory of Clignancourt, the manufacturer, far from hiding himself, announced everywhere the important work with which he was commissioned, and came to Sèvres to seek for painters of the first class. He had nearly succeeded in enticing away an artist considered to be indispensable to the manufacture, but the director, being warned in time, succeeded in persuading the artist to remain by means of an increase of 650 livres to his salary. Several similar examples might be given. Some years later the Count d'Angivilles, Regnier, director-general of the royal buildings, and the new administrator of the manufacture—showed themselves still more ardent in claiming what they called their rights.

From 1782, d'Angivilles appealed to the Committee of Finance, and addressed himself to the Lieutenant-General of Police, Lenoir, who, like his predecessor, was deputed to settle the disputes which might arise between the manufactory and its workmen, or the managers of other manufactories.

Lenoir, who was also himself an enemy of privileges, did not conceal his views, and argued that the small manufacturers reduced to the simple making of white porcelain, or porcelain decorated in *camaïeu* without any gilding, could never maintain themselves, and that in this case, artists and workmen would probably emigrate, and would compete with France. He also announced an offer which the manufacturers had made to give 2 per cent. of the produce of their sales to the profit of the royal manufacture; but all was useless. D'Angivilles, whether by conviction, or to show his zeal to the king, insisted on his decree, and obtained it, in spite of numerous petitions, supplications, memorials of all kinds which those interested addressed to the king.

By a decree dated May 16th, 1784, the royal manufactory was confirmed in all its privileges; the managers of other manufactories of the kingdom were allowed to make works of a medium size, designed for the use of the table, and for common use, to apply to them gold on

the borders only and to paint flowers shaded in all colours, on condition that they should transport their establishments, in three years at the latest, to fifteen leagues, at least, distant from the town of Paris, and in any other place than the chief towns of the provinces. Besides, it was forbidden them "under a penalty of 3,000 livres, to receive into their workshops any of the workmen employed in the royal manufactory, unless they showed a discharge signed by the director."

This was evidently a victory, but a victory which was to be absolutely sterile. When, at the end of three years, D'Angivilles wished to use his rights, and have the manufactories moved fifteen leagues from Paris, delays were asked which it was impossible for him to refuse, and when the Revolution, which was to suppress privileges, came, all the manufacturers threatened by the decree of 1784 were still at Paris.

It will be seen by this *resumé* what were the excessive privileges for which the ancient manufactory has often been wrongly reproached. It had no need of them, for the inimitable porcelains which came from the hands of its skilful artists obtained it a place so much above the other manufactories, that one cannot help regretting the narrowness of mind which made its directors claim rights absolutely useless, and which, without any profit to itself, could only injure an industry which it was its mission then, as now, to defend and protect.

It is impossible, however, to deny the happy influence which the manufactory exercised over the development of the manufacture and of the decoration of porcelain in France. At the price of incessant sacrifices it has established this manufacture, it has shown what money could make of a material which, it is true, others had discovered before it, but of which they hardly knew how to make any use. To its initiative, to its researches, we owe the discovery of the beds of kaolin, which gave a new impulse to an industry which was paralysed while it only had at its disposal the artificial paste. With this it had, however, created masterpieces, which the conditions of its existence, and the royal subsidy received from the treasury, alone enabled it to execute. It is, in fact, to the artists and workmen taught by it alone that is due that delicacy of taste, and that distinction which have placed the ceramic art at the head of the industrial arts of the last half of the 18th century.

IV.—The Manufactory from 1804 to the present time.

As already stated, the manufactory was in 1804 attached to the Crown, and administered in the name of the Emperor, who provided for its wants by annual budgets. This custom has been maintained ever since, notwithstanding the attempts which were made in 1830 and in 1848 to suppress the establishment. During a period of 47 years Alexandre Brongniart remained the director of the manufactory, and it was under his wise and active direction that it attained its highest degree of prosperity. During this period the manufacture of hard porcelain reached its highest perfection in France and in Europe. This was due almost entirely to this manufactory, and its processes were taken up by private establishments.

In 1847, Ebelmen succeeded Brongniart, and he showed himself a worthy successor to his wise predecessor. His management promised a new era of prosperity and glory to the manufactory, when death came to him in 1852. He was replaced by Victor Regnault, member of the Institute, who continued his management until the breaking out of the war of 1870, when he was forced by the bad state of his health to retire to his property in the Jura. Soon after, he lost his already illustrious son, the young painter, Henri Regnault, killed at Montretout by a Prussian ball, and he resigned definitively his functions. He was replaced by M. Louis Robert, chief of the painters' workshops, at the same time a distinguished artist and chemist, to whom he had on leaving entrusted the temporary management. In March, 1879, the latter was named honorary director, and had for his successor M. Charles Lauth, member of the Municipal Council of Paris, who was replaced in July, 1887, by M. Deck, the well-known ceramist.

In 1877, the manufactory had quitted the ancient building constructed by Louis XV., to be installed in a new building much larger, but much less convenient, situated at the extremity of the Park of St. Cloud, on the territory of the Commune of Sèvres.

During this long period the budget allowed annually to the manufactory has varied much. In 1812, under the Empire, it was 314,949 francs, then it was lowered to 120,000 francs under the Restoration, to be raised again, and to attain successively to 493,600 francs in 1872, to 507,450 francs in 1881, and then to 624,450 francs in 1889. Of this sum, 100,000 to 110,000 francs, coming from

sales made in the workshop, were returned every year to the State exchequer.

The staff of the manufactory is divided into two classes, the administrative staff and the working staff. The first comprises the director and the assistant-director, who is at the same time the conservator of the ceramic museum, the responsible agent, chief of the service, and seven clerks, among whom are the cashier, the storekeeper, the writing clerks, the guardians, concierges, &c. To this class a sum of 62,500 francs is reserved on the budget. All these are lodged on the establishment.

The working staff is divided into many departments, at the head of which are a chief of the works of art and the chiefs of departments.

The first comprises the manufacture of ovens and pastes, and possesses a chief of manufactures, an assistant, an overseer, and 55 sculptors, modellers, repairers, turners, firemen, and factory hands. The sum allowed to these is 129,000 francs.

The second department (decoration and bronze mounting) is carried on the budget for the sum of 117,300 francs. It comprises a chief of the workshops in painting, a superintendent, and thirty-five painters, gilders, and burnishers. The salaries of the artists are relatively moderate, and vary from 1,200 to 5,000 francs, but the payment for extra work increases a little the annual remuneration of the staff of this department. 16,500 francs are reserved for the third department, chemical works, and mufflers, directed by a chemist having five men under his orders.

To these officials, artists, and workmen attached to the manufactory, from whose pay a deduction of 5 per cent. is made to form a retiring pension, has been added an extraordinary staff as well as pupils, school professors, &c., for whom a sum of 143,000 francs is reserved. The balance of the budget, 129,350 francs, is devoted to the cost of materials, kaolin, precious metals, chemical products, tools, colours, combustibles, &c. Of this sum, a certain allocation is made to the museum and to the library; 5,000 francs alone being reserved for the acquisitions in the museum. This museum ought, in accordance with the wishes of its founder, the illustrious Brongniart, and of his old and much regretted curator, Riocreux, to form a general history of ceramics. But many gaps are found in the collection, which, owing to the limited resources at disposal, cannot be filled up.

The productions are priced on leaving the workshop, or valued if the piece is given as a present, according to their total cost, that is to say, the cost of the plain body, the money paid to the artist, the weight of gold used in gilding, the mounting, bronze, chasing, &c. To this is added 25 per cent. for expenses which it is impossible to estimate, such as colours, essences, firing, &c., and 40 per cent. for general expenses. Thus, a vase which has cost 800 francs will be priced for sale at 1,320 francs.

If we take account of the many trials, of the considerable expenses which attend the formation of a new model, and of the perfection which all productions leaving the manufactory with the device, "Decoré à Sèvres," ought to possess, this will not be considered too large a sum. If the manufactory sells little to the public—and we have seen that the annual sales scarcely rise to 110,000 francs, while the general production of porcelain for France amounts to from 40,000,000 to 45,000,000 francs—we must remember the presents made to sovereigns, services for ministers and ambassadors, gifts to charitable lotteries, to the commissions, to the exhibition juries, &c., &c., which all come from the manufactory. Besides, for the last dozen years there have been instituted annual competitions, which have not always given satisfactory results, but which have enriched public establishments, such as the Louvre, the Opéra, the Library, &c., with large decorative vases.

But this is not the only object of the manufacture; and we ought to examine the part which it has for fifty years taken in the progress of ceramics, and the influence it has exercised on French industry.

In 1850, in consequence of the Exhibition of National Manufactures, Mons. de Lasseyrie, in the name of the Council for the Improvement of Manufactures, instituted by a decree dated March 30th, 1848, thus began the report which he addressed to the Ministry of Commerce:—"Since they have passed from the Civil List to public management, national manufactures, &c., are found to be subject to quite new obligations; progress has become the very law of their existence. To make them rivals with private industry would be to misunderstand the object of their existence. Better placed to obtain the assistance of eminent artists and of *savants* of the first order, sufficiently endowed to undertake expensive trials and experiments, it was their task to open new ways for industry." And the learned reporter, passing in review

the different products exhibited, showed the improvements and the new processes brought to bear on the manufacture, as well as on the decoration of porcelain. Such as, among others, the process of *coulage*, or pouring slip into a plaster mould, to which a mere film adheres, applied to the making of cups and saucers. By this process they were enabled to make porcelain of an extreme lightness, rivalling the thin porcelains, which are so famous, of China and Japan, and which it would have been impossible to obtain either by turning or by moulding. Such also is the firing with coal, tried at the end of the last century, in the manufactories of Lille and of Valenciennes, which was abandoned, but was again taken up by the learned director Ebelmen, with the assistance of Mons. Vital-Poux, then chief of the ovens and pastes. This substitution of coal for wood enabled them to obtain a saving of two-thirds in the expenses of firing, and must have profoundly modified the conditions of production and existence of porcelain manufactories in France.

As applications of new processes of decoration, the report mentions some vases decorated under the glaze of the porcelain with sculptured ornaments in relief, *pâte sur pâte*, a process invented by M. Louis Robert, who was, as we have said, director of the manufactures, but who at this period was chief of the painters' workshops. These vases are painted with oxide of cobalt before baking, and under glaze. Also the decoration of porcelain biscuit by means of colours applied as in painting enamels was proceeded with.

Since this time, many of the processes have been much perfected, especially the process of *coulage*, which has been applied to the making of colossal pieces, such as the vase called "Neptune," which is 3·15 metres high and 1·17 metres diameter; also the coloured pastes with which—thanks to the learned researches of the eminent chemist of the manufactory, Salvetat (died in 1882), who knew how to combine the metallic oxides so as to obtain an almost complete gamut of colours—one can decorate a vase entirely under the glaze, and thus obtain a unity of tone and an intensity of colouring which could not have been given by the manner of painting previously employed.

Faithful to its mission, the manufactory of Sèvres has liberally divulged to private enterprise these various processes, as well as many others discovered since, and it cannot be denied that considerable influence has been exerted on modern ceramics by the numerous inventions that have issued from the State-aided manufactory.

The Exhibition of 1850 may be considered as the point of departure for important modifications brought into the porcelain industries by these processes, which were then quite new.

The process of colouring *au grand feu* is certainly that which has made the greatest progress, and among all the services rendered to the ceramic industry by the manufactory, that of having been able to introduce the preparation of colouring matters capable of resisting the high temperature of the porcelain fire, will not be considered the least. After long and difficult researches, and continued study, it became possible to define exactly the atmospheric conditions (neutral, oxidising, or reducing) which affect in a constant manner the shades which the same oxide will produce, and to predict the colour it will furnish.

Artists naturally took the greatest interest in this new method of decoration, which offered them infinitely varied resources, and allowed a vigour and a richness of colouring which the processes of painting used hitherto had not afforded; and, in fact, the colour applied to the porcelain biscuit was developed in the fire, and acquired under the glaze of the enamel a depth, an intensity, and a heat which it would be impossible to obtain with the colours of the muffle. Nearly all the painters of Sèvres, in spite of the difficulties caused by the new mode of employment, which partakes both of painting and sculpture, have succeeded in producing remarkable works.

Polychromatic decoration has made the greatest progress in the last fifteen years. Some years after the exhibition of 1850, where, as we said above, the first trial of coloured pastes had been timidly attempted, important works were commenced by Salvétat; and a skilful sculptor had executed with the new paste a series of little vases, representing, in white paste on a coloured ground, and ornamented with flowers and ornaments of different colours, subjects taken from La Fontaine's Fables. This series, exhibited in London in 1862, and highly spoken of at the time, is now in the ceramic museum at Sèvres, where it will remain as a precious monument of the history of ceramic arts.

Some colouring matters are more fusible than the white paste, while others are less fusible. This caused considerable difficulty, especially for large pieces. Many accidents occurred in the firing, as the paste rose in

flakes, shrank, or scaled off, and considerable deformations took place. The artist often saw the result of the labour of many months destroyed in a few hours under the influence of the fire. Nothing less was needed than the persistence of the learned Regnault, and the indefatigable perseverance of Salvétat, in continuing the researches already begun, in order to obtain some fixed principles, which, if they could not altogether prevent might diminish the chances of such accidents. Now, those rare accidents which occur in the firing are mostly produced by a defective employment of the colouring matter, due to inexperience, which practice soon remedies.

The most simple and widely used process, and that which has revolutionised the conditions of ceramic industry, consists in ornamenting the porcelain with white barbotine on a coloured ground. The object is modelled and produces various degrees of transparency, according to the thickness of white paste laid on; the cameo effects obtained thus being truly remarkable.

By the side of these processes of manufacture and ornamentation we may cite others of less value, but which are not therefore without importance, and by which private enterprise has largely profited. Such are the paintings, *au demi-grand feu*, by which hard porcelain thus decorated receives a glaze almost equal in artistic effect to that of soft tender porcelain. The figured gold, and the golds modelled into transparency, the application of opaque and transparent enamels, used thickly, &c., and many other processes, prove that the manufacture of Sèvres, faithful to its mission, seeks continually to move forward in the van of scientific progress.

The next Paris Exhibition will contain specimens of kaolinic porcelain texture with soft glaze, the fabrication of which, commenced by Ebelmen in 1848, and continued by Salvitat, has been perfected by Messrs. Lauth and Vogt, with new grounds of *celadon* and turquoise, which Mons. Deck is applying to pieces of soft porcelain of a size which appeared until now impossible to obtain.

We may see from what has gone before that, from the point of view of technical processes, the manufacture of Sèvres only merits eulogium; as to the artistic question, we have not to examine it here in detail. The products of Sèvres have often been reproached for being too academical in treatment, and too conservative, in not presenting sufficient variety, suppleness in the decorations, and originality in the artistic ideas. Private industry being independent, allows its artists to exhibit more dash, more devices for novelty, and more boldness. But how can these qualities be given to a State manufactory? All the supervision is directed to the curing of defects, but at the same time the characteristic qualities of original inspiration are also eliminated. Novelties cannot be expected from a State establishment.

In summing up, it may be said that we cannot have at the same time a State art and a free art; a faultless art and an original art; a correct art and a progressive art. In artistic matters, a State institution cannot really open new ways, it can only carry on and maintain in their perfection a style and and a manufacture already created. The manufactory of Sèvres fulfils its duty admirably, and it would be an injustice to ask it to do something else.

The paper was illustrated by lantern slides of specimens of Sèvres, from the collection of Her Majesty the Queen, at Buckingham Palace. Mr. George Donaldson exhibited a cup and saucer, of "Rose du Barry;" Messrs. Mintons, vases and bouquet holders; and Mr. Starkie Gardner two cups and saucers of egg-shell china.

DISCUSSION.

Mr. JOHN LEIGHTON said he knew Sèvres very well, and regretted there were so few specimens of the genuine manufacture shown. The two Minton vases were very beautiful examples of the *pâte sur pâte*, such as M. Deck, the Director, showed him in Paris. They were exceedingly artistic because the figures were really painted up and modelled with the brush. With regard to factories subsidised by the State, the porcelain works at Sèvres was an example both of what to admire and what to avoid. The admirable works produced there were created regardless of cost, or nearly so, and some were produced which entered into competition with private enterprise. In the olden time the directors of Sèvres were neither artists nor manufacturers, but simply administrators, though they were often led by artists of the establishment with advantage. For instance, Hammon, a painter, exercised an immense influence in the introduction of the *style tendre*, before he went there everything being in full colour; he introduced a sort of semi-classic style which had a great power. He did not think it would be well in this country to copy either the Sèvres or Gobelins factories, even with such able men as Deck or Gaespach at their head. Deck left a fabric which he had created in Paris for the produc-

tion of artistic faïence, of which it might be said that it was well done because it was done quickly, so unlike the porcelainerie of Sèvres, which depended upon time, enrichment, and elaboration. Nearly all Deck's work was done with speed, and he had a regular association or club of artists, that his factory was quite the antithesis of Sèvres, yet at the present time he was the administrator there. The material was quite different, his own work being faïence, whilst this is porcelain, the clay for which comes from Limoges. Doubtless Deck would change the nature of the Sèvres porcelain ware and leave his impress upon the place, but it was very difficult for a director of a national factory, where the *employés* were subsidised and dwelt upon the premises, to enter into a spirit of rivalry or competition. He had been round the works with Deck, and noticed that he was obliged to be particularly discreet with the men, and could hardly criticise what they were doing; in fact, it was a most difficult position. France certainly had some remarkable art works at Limoges, so renowned of old, where works of great individuality were produced, especially in the old Albert Dürer style in gold, white, and blue. Perhaps in the whole world there did not exist a unique industry like that of Bazbedienne, in Paris, which combined the greatest art with the highest industrial efforts of man; what Bazbedienne had done for bronze, Deck had done for faïence. Bazbedienne, however, had not been subsidised by the State, whilst Deck had become a director. He doubtless would elevate Sèvres, but it was doubtful if his own works at Vaugiraud did not miss his master mind. He knew that the specimens of Sèvres in London were highly appreciated in France as curiosities and samples of form, being of great historical interest, although many were crude in colour and heavy. The introduction of metal and the insertion of metal cores seemed hardly fair in porcelain, but some of the vases were monuments, not lifted whole, having to be built up piecemeal. Sèvres would of course be well represented at the forthcoming Exhibition, and he knew that the influence of Japan would be much felt. There would be several novelties exhibited, especially in *pâte sur pâte* employed in a new way. As to the appointment of so able a man as Deck, it was rather remarkable that this was the first time that a porcelain manufacturer had been taken up by the Minister of the Fine Arts to preside at Sèvres.

The CHAIRMAN said it was his pleasing duty to propose a vote of thanks to Mr. Garnier for his admirable paper, and to Mr. Gardner for the trouble he had taken in translating it, and for his additional notes. He would not detain the meeting by any remarks of his own, except to express his satisfaction that Mr. Gardner had called attention to the absence ot any fine specimens of early Sèvres at South Kensington. They were indebted to the munificence of donors in these matters, the late Mr. Jones having given a very fine collection, and he hoped when it was known that they were deficient in early examples, some gentlemen might think it worth while to improve the national collection by presenting specimens.

The vote of thanks having been carried unanimously,

Mr. STARKIE GARDNER, in responding, said he felt it was a great pity that this magnificent industry in England should not be located in the natural home where one expected to find the potteries, viz., where the clay was found. The kaolin district in Cornwall, near St. Austell, was a most lovely spot among hills, exposed to the fresh breezes from the Atlantic; the Devonshire kaolin district was at the foot of Dartmoor, and was also wild and beautiful; and the pipeclay district near Corfe Castle in Dorsetshire, backed by hills, and sloping to a sheet of water like an Italian lake, was as beautiful a place as any in England. If the potteries were only taken there, instead of being located in Lambeth or London, where the unfortunate workmen where housed in the slums, they might live in the purest and best air of England, and their children might grow up to be healthy and stalwart lads, instead of pining under every disadvantage as they did at present.

ELEVENTH ORDINARY MEETING.

Wednesday, February 20, 1889; Sir FREDERICK BRAMWELL, Bart., D.C,L., F.R.S., in the chair.

The following candidates were proposed for election as members of the Society:—

Beale, Frederick, Gas Works, Beckton, E.
Butcher, William Deane, M.R.C.S., Clydesdale-villa, Windsor.
Griffith, Samuel Clewin, M.D., 45, Finsbury-square, E.C.
Hamilton, Thomas, 46, Parliament-hill, Hampstead, N.W.
Morse, Sydney, 4, Fenchurch-avenue, E.C.

The following candidates were balloted for and duly elected members of the Society:—

Hall, Sir Basil F., Bart., Dunglass, Cockburnspath, N.B.
Hardinge, Viscount, South-park, Penshurst, Kent.
Lawson, Vincent Alexander, 9, Rowcroft, Stroud, Gloucestershire.
Newton, Alfred James, Sheriff of London and Middlesex, Northwood, Chislehurst.
Thomas, William Kingdon, 16, Berkeley-place, Clifton, Bristol.

The paper read was—

THE FORTH BRIDGE.

By Benjamin Baker, M.Inst.C.E.

Rather more than six years ago I read, at the request of our ever-to-be-remembered friend, the late Sir William Siemens, my first paper on the Forth Bridge. I did it under protest, as the designs were not then matured nor the contract let; and I prefaced my paper by saying that I "would have preferred to postpone any communication on the subject until the works were well in hand and the many points of interest and difficulties inseparable from so gigantic an undertaking had manifested themselves." That time has now arrived, for we look for the completion of the bridge in the autumn of the present year, and although very probably new points of interest and difficulty will arise between now and then, I have sufficient material in the work already accomplished for more than a hundred lectures. I can indeed attempt nothing more in the time at my disposal than to convey to you some general idea of the magnitude of the design, and the mode of executing the Forth Bridge; in short, I promise no more than to give, with the aid of the photographs which I shall throw on the screen, what may be regarded as an illustrated table of contents of a descriptive treatise on the bridge, which no doubt will have to be written in the future by some one.

I may begin by saying that the design of the Forth Bridge is a compromise. Sir John Fowler and myself prepared the original design, and Mr. Barlow, on the part of the Midland Railway, and Mr. Harrison, on the part of the North-Eastern Railway, asked for certain modifications in detail which in the end we had to accept. If we had to do the work again, with our present experience, I doubt if some of these modifications would be insisted upon, whilst others would be made. But six years ago we were of course, metaphorically speaking, traversing a trackless jungle, and not following a beaten path.

In preparing what I have termed the illustrated table of contents which I propose to present to you to-night, I thought it would be most convenient to give first of all a general notion of the situation, the size, and the principle of design of the Forth Bridge, and then to describe briefly the mode of executing the piers, and manufacturing and erecting the superstructure of the work, depending, in all cases, more upon the photographs than upon my own words for conveying to you some idea of the operations.

Situation.

The Firth of Forth, as everyone who has glanced at a map knows, cuts Scotland almost half in two, and its broad and deep channel has always offered a great impediment to traffic between north and south. It is no matter for surprise therefore that suggestions for facilitating communication across the Firth have been numerous during the past 100 years. In 1804, an enterprising and fearless Edinburgh surveyor published designs for a bridge across the Forth, at the same spot and with spans of the same size as the present structure. He proposed a suspension bridge, and from experiments made with a short piece of chain, hung from posts like a clothes line, he came to the conclusion that about 200 tons of iron would do the job, and the cost of the work was to be something less than six months' interest on the cost of the present Forth Bridge. To come to recent times and modern requirements, it is needless to remind you of the "race to the north" last autumn between the east and west railway companies. Fourteen years ago it was seen by the directors of the several companies forming the east coast route that the Firth of Forth was the weak link in their chain of communication from north to south, and it was to that point therefore that they wisely addressed themselves with a view to improvement. At first, the enormous spans required for a crossing at Queensferry, though cheerfully faced a century ago by the Edinburgh surveyor already referred to, daunted the modern engineer, so an Act of Parliament was first obtained for a bridge higher up the Forth than Queensferry. Subsequently, however, it turned out that, although we have changed in our views not a little since 1804 as to the design of the bridge, the Firth of Forth itself has not changed. Now, as then, the best site for a bridge is at Queensferry, where the estuary narrows, and the island of Inchgarvie stands like a giant stepping-stone in the middle of the stream to help the way across. On each side of the island the channels are over 200 feet deep, and so the necessity arose for building a bridge having two spans of the unprecedented magnitude of 1,710 feet each, to clear the deep channels at one jump.

Size.

It is not easy to realise how vast is the difference in scale between a 1,700-feet bridge

and all other railway bridges hitherto constructed. The largest bridge in this country—the Britannia tubular bridge across the Menai Straits—has a span of 465 feet, therefore the Forth Bridge spans are $3\frac{2}{3}$rds times as great. This arithmetical comparison will probably not help you much in itself, but I may assist your imagination by mentioning the fact that a $16\frac{1}{2}$ hand high hunter is just $3\frac{2}{3}$rd times the height of a well-bred harrier, which, as you are aware, is a much smaller dog than a foxhound. Each of the Forth Bridge spans would take you at one bound from the Strand, over the hall we are in; across John-street, Adelphi-terrace, the Thames-embankment, and the river itself, to the Surrey side. The height of the steel work is also exceptionally great, being equal to that of the golden cross at St Paul's, but this may be best shown by a diagram of the comparative heights of different buildings.

Principle of Design.

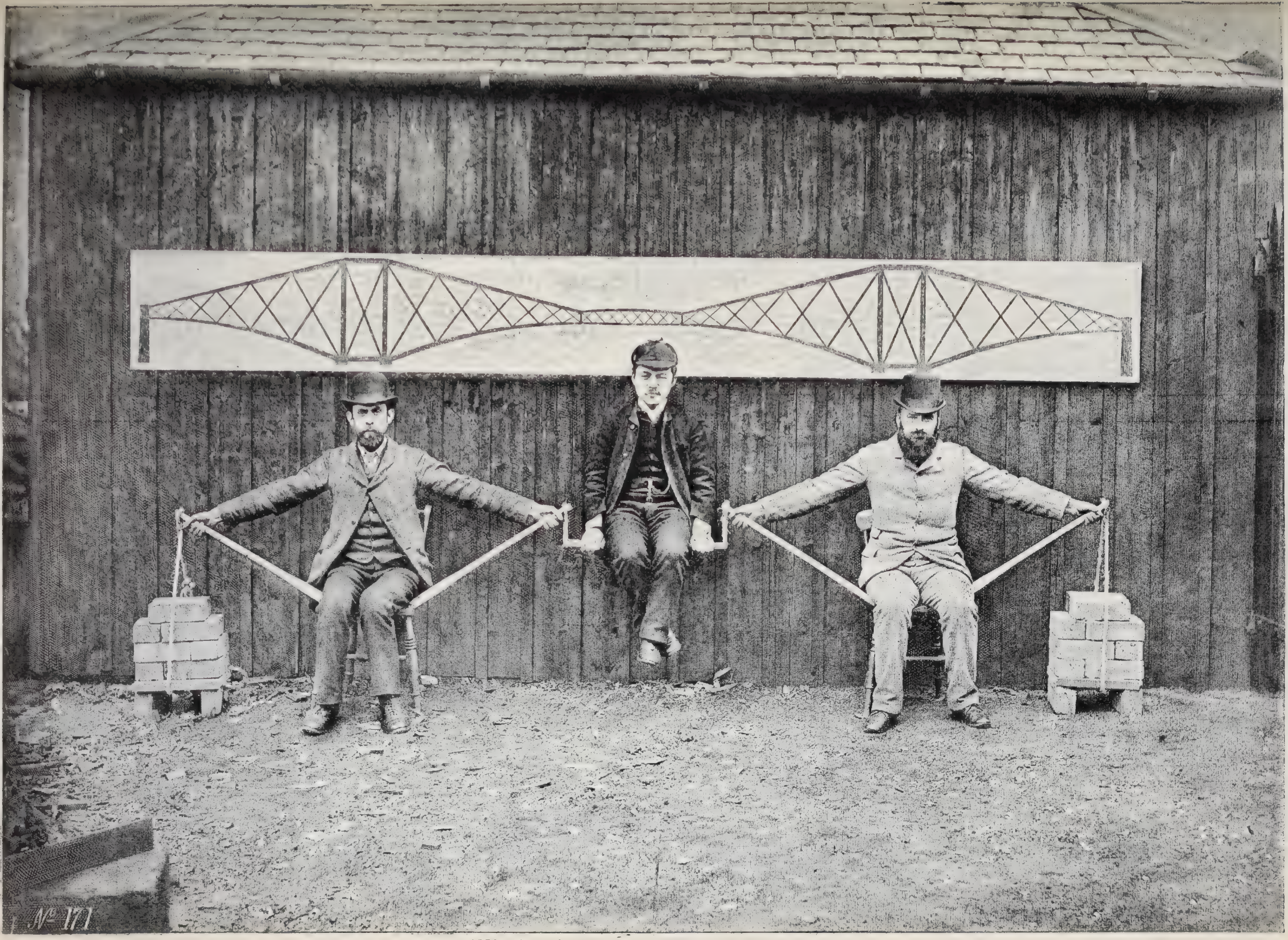
When I was a student, a girder bridge which had the top member in tension, and the bottom member in compression over the piers was called a "continuous girder bridge." The Forth Bridge is of that type, and I used to call it a continuous girder bridge; but the Americans persisted in calling all the bridges they were building on the same plan "cantilever bridges," so I yielded the point, and the system will be so designated in Dr. Murray's new English dictionary. "Cantilever" is a 200 year old term for a bracket, and the Forth-Bridge spans are made up of two brackets and a connecting girder. Imagine two men trying to shake hands across a stream a little too wide for their hands to meet. One man extends his walking stick, and the other one grasps it, and so the stream is bridged. There we have the two arms, or brackets, and a connecting girder. In the Forth Bridge the arms are supported by great struts, as in a living model, which I showed at the Royal Institution a couple of years ago, where raking struts extended from the men's wrists to the points of support (Plate 1). The principle of bracket and girder construction is as old as the hills, for it lends itself peculiarly to timber construction, which we know in primitive times preceded masonry.

Piers.

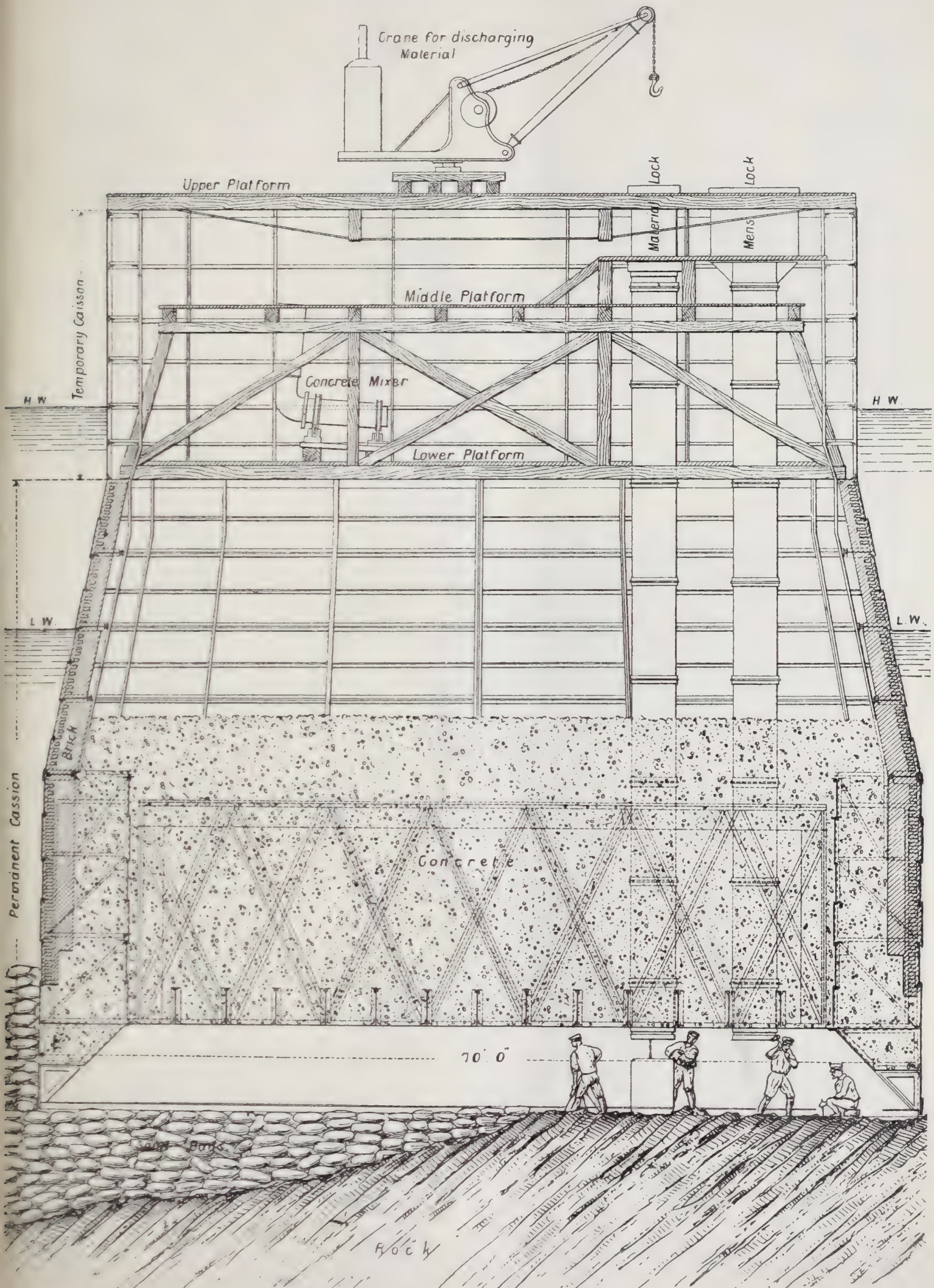
Each of the three main piers includes four columns of masonry and concrete from 50 feet to 70 feet in diameter, founded on rock or boulder clay, at depths ranging up to 90 feet below high water. I must content myself with describing briefly one of the twelve piers, which all differed somewhat in detail, and I will select one of the Inchgarvie piers, founded on a sloping fissured rock bottom, at a depth of 72 feet below sea level, in a very exposed and stormy estuary. The method adopted was as follows:—A huge wrought-iron bucket, or caisson as it is technically called, 70 feet in diameter, and between 50 feet and 60 feet high, was built on launching ways like a ship. The bottom of the caisson was set up 7 feet above the cutting edge, and so constituted a chamber 70 feet diameter, and 7 feet high, capable of being pumped full of compressed air, so that the men could work in it below the water, as in a diving-bell (Plates 2 and 3). The ironwork weighed about 500 tons, and when towed out to position the added concrete and brickwork brought the total weight up to 2,700 tons. Additional concrete was then filled in, and when the weight reached 3,300 tons the caisson grounded on the sea bottom, where a bed had been prepared for it with sand-bags, the workmen entered through air-locks, and the rock excavation proceeded in this electrically-lighted chamber as safely as on dry land. The air-pressure in the working chamber was at times as high as 35 lbs. per square inch. We say the barometer is high if it stands at 31 inches, but in the working chamber it often stood at 72 inches. When Coxwell made his high ascent the barometer fell to $7\frac{1}{2}$ inches, or about one-tenth of the preceding height, which illustrates how marvellously the human mechanism is adapted to sustain wide variations of atmospheric pressure.

Manufacture of Superstructure.

The superstructure of the Forth Bridge has required the manufacture on the spot of about 50,000 tons of steelwork. As a rule, the compression members consist of tubes, and the tension members of lattice girders. This arrangement, as was anticipated, is, from an architectural point of view, most effective, for seen against the sky background, all columns and struts show up in strong, dark lines, whilst the ties look like delicate tracery. In making the tubes, the plates were bent hot, the edges planed, and the plates built up temporarily into long tubes, to be drilled by traversing machines through the whole thickness of plates. In practice, I may mention that our steel plates, having an average tensile strength of 34 tons per square inch, drill more readily than iron plates of 22 tons. We have at times turned out as much as 1,800 tons of steelwork



LIVING MODEL OF THE FORTH BRIDGE.



INCHGARVIE MAIN PIER CAISSON.

LAUNCH OF INCHGARVIE CAISSON.

FIFE TOWER.

per month at the Forth Bridge works. As regards trustworthiness of steel, in no single instance have we had a failure or even cause for anxiety out of the hundreds of thousands of steel plates, bars, and rivets which go to make up the superstructure of the Forth Bridge.

Erection of Superstructure.

In ordinary cases bridges are built on scaffolding, but owing to the great depth of water and other considerations, this would obviously be impracticable in the case of the Forth Bridge. The method determined upon was to first build the great steel towers 370 feet high, and then to add successive bays of the cantilevers right and left, until the whole was complete. The central connecting girder will be similarly erected in two halves, temporarily connected with the projecting ends of the cantilevers. This system offers great advantages as regards safety during erection, for there is no critical time, every part being securely bolted up as the work goes on. We have had ample evidence of this, for at no time have we suffered any danger from storms; and a few weeks ago, during a very heavy gale, the maximum movement even in the unrivetted part of the work was under half an inch.

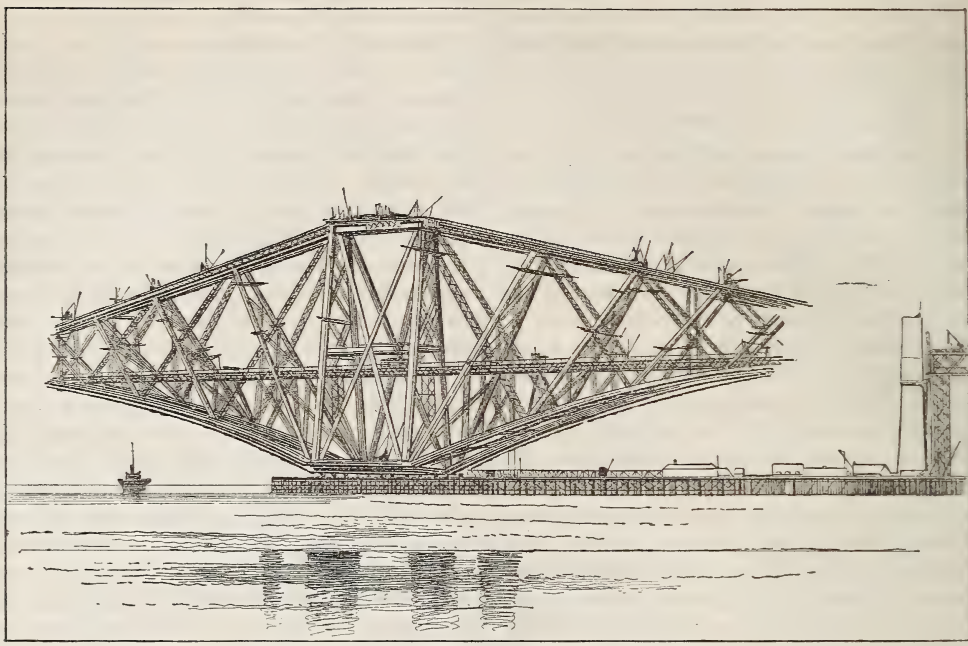
The great towers were erected with the aid of lifting-platforms and cranes raised gradually from ground level to the full height of 370 feet by four hydraulic rams, one in each main tube. As the platform was raised, all the work immediately above and below it was built, bolted, and rivetted. The first half bay of each cantilever was similarly erected (Plate 4).

Our experience so far has been that, whilst the work of erection has been somewhat slower and more costly than we anticipated, it has, on the other hand, been less difficult, and subject to fewer contingencies. We thought at first that the cranemen and erectors would require practically to be close together, but we have found out, or rather the men have found out for themselves, that cranes 370 feet up in the air can handle work at ground level, and that the long steel-wire ropes hanging from the crane jibs, instead of being destructive of their usefulness, are often of great advantage, as plates and bars can be swung out pendulum fashion to a distance far beyond the reach of the jib itself. This result of experience, combined with the boldness of the men, enabled us to dispense with the use of lifting platforms for the outer bays of the cantilevers, and in lieu of this mode of erection, to use steam cranes travelling on the top member and internal viaduct, commanding therefore all the steelwork below. With increased experience, we have erected as much as 2,350 tons of steelwork in a single month.

Everything in connection with the Forth Bridge, except the rolling of the steel plates, has been done on the spot. This has necessitated the establishment of one of the largest bridge-building works in the kingdom, capable of turning out 1,500 tons to 2,000 tons of finished girder work per month, for the special purposes of the Forth Bridge. As the cost of these works has to be charged to a single undertaking, instead of distributing the cost, as in ordinary manufacturing works, over many, the expenses in connection with the Forth Bridge are necessarily heavy. More than £500,000 has been expended on machinery, staging, railways, steamers, buildings and lighting The granite piers have cost about £400,000, and the steelwork about £1,300,000 in addition; 42,000 tons of steelwork have been erected up to the present date, and a good deal more is ready for erection. It is believed that the bridge will be finished in October. Mr. Arrol has charge of the operations, as chief contractor, with Mr. Biggart as chief asssistant. Mr Stewart has had responsible charge of the drawings and the chief resident engineers have been Mr. Cooper and Mr. Meik.

The number of men employed on the works has, at times, been as high as 4,300. The average number during the past five years has been 2,300. Much of the work at the Forth Bridge requires men possessed of coolness, courage, and other qualities characteristic of the finer specimens of humanity, irrespective of nationality. The lantern views exhibited will have brought vividly home to you the fact that the men erecting the bridge have to dismiss from their minds all unpleasant reminiscences of what students of dynamics call "the motion of a falling body under the unbalanced action of its own weight," for any nervousness on the part of men lying out along a projecting angle bar, as many do, with a clear fall of between 300 and 400 feet below them, would only lead to an unnecessary verification of Newton's laws respecting the accelerating force of gravity. Unfortunately, men have fallen from all heights on to the staging or into the sea. In most cases the falls arose from the too reckless courage or indifference of the men; in some few cases from the fall of staging. One instance of the latter class was mentioned by me at Dundee some time ago,

FIG. 5.



SOUTHERN CANTILEVER.

FIG. 6.

GENERAL VIEW OF BRIDGE.

and has since gone the round of the world, being cited in American and Colonial newspapers as an instance of modern heroism. Six men were on a stage, which suddenly gave way, leaving half the number hanging to the steelwork, and letting the other half take the headlong plunge of 140 feet downwards. One of the men left hanging declined the assistance offered him until his companion was first rescued. As an instance of indifference, I need only mention the case of a man who, carrying a lump of coal on his shoulder, stood on the fence-rail of the topmost platform, and overbalancing, fell backwards the full height of 360 feet. A fruitful source of accident is, of course, falling bodies, planks, hammers, drifts, and other tools dropped by men on their fellow-workmen below. We take all possible precautions, by arranging wire nettings, to intercept falling objects, and often find drifts, nuts, and bolts, which have come down like bullets on these nettings at the average rate of one per square yard, but nothing avails if the men themselves are indifferent to their risks. Some physiologists contend that we of the present day have more highly strung nerves than our ancestors; but if I am to believe what I read in the 1797 edition of the *Encyclopædia Britannica*, under the article "Bridges," and remember what goes on daily, as a matter of course, at the Forth Bridge, I doubt this assertion. The writer of the article referred to, speaking of a natural bridge across a ravine 205 feet deep says: — "Though the sides of this bridge are provided in some parts with a parapet of fixed rocks, yet few men have a resolution to walk to them and look over into the abyss. You involuntarily fall on your hands and feet, creep to the parapet, and peep over it. Looking down from this height about a minute gave the author a violent headache." Well, all I can say is, that I see more than one lady present to-night who, not content with going merely to the top of the bridge, would insist upon my taking her out to the end of the slewing jib of the 50-feet cranes to get a clearer view of the waves rolling 300 or 400 feet beneath our feet. As for the men, they know no difference between four feet and 400 feet.

The loss of life, so far, has been about half a hundred, which, having reference to the number of men employed, is a rate of mortality about two-thirds of that which occurs with the guards and brakesmen of goods trains; so there are far more dangerous employments than erecting the Forth Bridge.

We have now been at work at the bridge for six years, and I may be reasonably asked if all of the anticipations formed by Sir John Fowler and myself have been realised. Well, I am happy to say that, so far, the anticipations of the croakers have been falsified. Six years ago, the late Astronomer Royal wrote to the papers, saying that "the safety of the structure depends entirely upon a system of end thrusts upon very long rods; there is a liability to ruinous disturbance by the lateral power of the wind. The proposed construction is not a safe one, and I should be happy to hear that it is withdrawn."

The "rods" referred to by Sir G. B. Airy are the 12-ft. diameter tubes which have stood forth so prominently in many of the views exhibited to-night; and, as I have already said, so far from there being any ruinous disturbance from wind action, even in the incomplete work, the "very long rods," and every other part of the structure, are as steady as a rock during the heaviest gales.

The best test of the success of an affair, however, is to see whether other people are inclined to follow your lead. In that respect we have nothing to complain of, for since the commencement of the Forth Bridge many important bridges have been successfully completed on the same plan, and the contractors have in all cases been well satisfied with the economy and speed of the operations, and the stability of the structure at all stages of the work. The Forth Bridge at present heads the list of great bridges, but it may soon be displaced. Last year a charter was granted for a 2,800 feet span bridge at New York, and Mr. Lindenthal, the engineer, asked me to assist him in this matter. Our enterprising idealist friends on the other side of the Channel will be satisfied with nothing less than a bridge from Calais to Dover; and a few days ago the great firms of Schneider, of Creusot, and Hirsent, the original contractor for the Suez Canal and early part of the Panama Canal, brought over to me their preliminary designs for discussion. As an engineering question, the works we have done in the way of large spans at the Forth and deep foundations at Sydney have placed beyond doubt the practicability of a Channel bridge, but of course the enormous cost precludes the question being one of other than scientific interest. There is, however, unundoubtedly a great future before bridge

builders. Only 90 years ago the standard definition of "bridge" was "a work of masonry or timber, built over a river or canal for the convenience of passing the same." There was no mention of iron, nor was there of railway. In scientific treatises suspension bridges were referred to, for some forgotten reason, as "philosophical bridges." The introduction of cheap steel will account for a good deal of the progress in modern bridge building, but not all; for if the Forth bridge were built of iron instead of steel, of the same scantling, it would still be stronger than either Stephenson's great bridge across the Menai Straits or Brunel's Saltash bridge. The fact is that a great bridge, like all great things, is a product of the age—a resultant of many forces—and not the work of one nor of a hundred individuals.

DISCUSSION.

The CHAIRMAN having invited discussion, to which there was no response, said he was not surprised that no one rose, for the paper, coupled with the admirable illustrations, afforded absolute information on every point, and except with the object of requiring information, there was not much room for remark. The paper contained a description of certainly the most extraordinary work that he knew of in any branch of engineering. This bridge was rapidly approaching completion after years of hard work. The foundations, which in themselves, although not unprecedented, were works of great magnitude, and must have been the cause of great anxiety, having regard to the shelving character of the central foundation, had been successfully accomplished; the piers were in their places, and had a large portion of the total superincumbent weight upon them, which they had stood perfectly well. With respect to the effect of the wind, they had more experience of that now than they would have when the bridge was finished, because there was an enormous per-centage of the whole work which would be exposed to the wind action already completed, but the bridge, as a whole, was in an uncompleted condition, and it must be said, therefore, that when it was completed it would not be so severely tested by the wind pressure as it was at the present moment. Mr. Baker would, in a few words, be able to tell them how much of the total weight of the superstructure was devoted to the purpose of withstanding wind pressure, but he believed it was a very large proportion of the whole. Nothing was much more striking than to look at this enormous framework, and see that its object was to carry the central roadway, which was all but lost in the midst of that which supported it. The actual roadway on which the trains would run was quite insignificant compared with the structure which carried it; and as regards the live load, the bridge would know as much about the trains passing over it as an elephant would of a bluebottle settling on its back. It would be absolutely a matter of indifference whether there was one train upon it or ten. In this respect it was totally different to an ordinary bridge. The real load on the bridge was its own weight, and nothing was more striking as bridge spans increased than the need there was to increase, in a much greater ratio, the height of bridges at the points whence they derived their strength; if it were an arch, the depth of the arch at the sides, or in a cantilever bridge the depth or height of the part which formed the root of the cantilever. These proportions had to increase enormously as compared with the span, or else it would be impossible to make a bridge even self-sustaining. The problem was first to make the bridge sustain itself, and having done that, it was very easy to provide for the load which passed over it. The other problem was the mode of resisting the wind pressure, and they knew the enormous pains which had been taken by Sir John Fowler and Mr. Baker in calculating the effect of the wind in this structure. Continuous observations had been made on the wind pressure by means of an anemometer such as had never been seen before in point of magnitude, which had been in operation for some years, and had afforded results of the greatest value from a scientific point of view. There were, therefore, all requisite data for judging what the wind pressure would be when distributed over a large surface, not isolated on some small surface, as it would be in an anemometer of the ordinary construction. Then, having ascertained this, the question arose how this pressure was to be resisted, and nothing could be more satisfactory than the manner in which this problem had been sought out and happily solved by the engineers of this bridge. He trusted that when at the Newcastle meeting of the British Association Mr. Baker fulfilled his promise of giving the workmen's lecture on the subject of this bridge, he would be able to show photographs in which the bridge would be shown still nearer to completion than it was in those exhibited that evening. As a matter of form, he would ask the meeting to pass a hearty vote of thanks to Mr. Baker for his paper.

The vote of thanks having been passed unanimously,

Mr. BAKER, in replying, said it must be very gratifying to any reader of a paper to have the opportunity of delivering it before such an audience, and it was always especially pleasing to him to have Sir Frederick Bramwell as chairman. As usual, Sir Frederick had put his finger on the most important point in the whole design, the provision to resist wind pressure. It would be seen from the complicated appearance of the structure in some of the

photographs what a network the whole thing was, whereas on the diagram it only looked like a single plane surface, the number of square feet in which, multiplied by the wind pressure per square foot, would give the pressure of the wind which might come against it. But taking a perspective view, it showed that behind the front surfece there were no end of lattice work girders, the area of which might be anything. The way he began the investigation was to make a metallic model of the bridge exactly to scale, with every cross-piece and strut, and then to put it into water, and tow it slowly behind him in a boat, the model being attached to one end of a bar, at the other end of which was a flat plate, the area of which he could vary at pleasure. This plate was regulated until it exactly balanced the resistance of the model of the bridge, and then by measuring the area of the plate he found the equivalent area of the model, and from that of the bridge itself. It was about double the front surface, as shown on the diagram. Having got that, the Board of Trade Rules said they must provide for a wind pressure of 56 pounds per square foot. From the wind gauges which they placed at different parts of the structure, they could not see much difference in the pressure at the top and at the bottom, though as indicated by one's own personal feelings, you would be infinitely happier at the top than down below. Up 400 feet you were out of the cold damp feeling which came from the water, and there seemed much less wind, as it was so broken up by the structure below. Several persons whom he saw present had expressed the opinion that on the top of that bridge was where they would like to live. The wind pressure on each span was calculated at 2,000 tons laterally, whilst the heaviest trains would be two coal trains of 400 tons each, or 800 tons in all. The lateral action of the wind, therefore, would be two and a-half times as much as the heaviest trains, and you had to pay a great deal more attention to the wind than to the trains. The essence of the design as regards wind pressure was the straddleleg arrangement of the main columns and streets. The top member had no cross-bracing at all, because whatever wind pressure came there had finally to come down to the masonry piers and the rock. Since everything had to come to the ground ultimately, obviously the principle was to take it down by the shortest route, and the shortest route always was from the top member down the nearest strut. It resulted from this that the heaviest stressed portion of the structure was the lower tube at the piers, which had to bear the wind pressure, the dead load, and the live load. The stress at the top member was 4,000, and at the bottom nearly 7,000 tons. As a matter of fact, the stress on the tube from the weight of the bridge was 2,700 tons, and when the heaviest trains came on you might put on 40 per cent. more, or about 1,100 tons; but the wind put on 3,000 tons, or more than either the dead load or the live load.

FOREIGN & COLONIAL SECTION.

Tuesday, February 19, 1889, the Earl of DUNDONALD in the chair.

A paper on "Slavery, in its relation to Trade in Tropical Africa," by Commander V. LOVETT CAMERON, C.B., R.N., was read.

The paper will be printed in the next number of the *Journal.*

CANAL NAVIGATION.

Models of Mr. Pickard's new system of Canal Navigation were exhibited in the Library of the Society of Arts, on Wednesday evening, 20th inst.

The inventor proposes to divide each canal by a thin mid-feather, or diaphragm, at one extremity of which, below the water level, is placed a fan, on the principle of the screw-propeller, set in motion by means of a stationary engine, and throwing the water from one side of the mid-feather, causing a depression, to the other side, creating an elevation. The effect of this simultaneous accumulation of water on one side and abstraction on the other is to create a current circulating round the further extremity of the mid-feather left open for the purpose. On this current Mr. Pickard proposes that boats specially constructed for merchandise shall be floated and capable of navigating themselves without any attendance or steering.

Miscellaneous.

MINING INDUSTRIES IN SIAM.

Siam is rich in minerals. Gold, iron, tin, and copper are found in many parts of the country, but the want of roads, and consequent difficulty of getting these metals to market, prevent their being worked, except for the limited wants of the natives. Consul Child of Bangkok says, in his last report, that the eastern part of Siam is very rich in iron, antimony, and argentiferous copper and tin. It is from the provinces of Petchaboon and Löm that the cutlasses, spears, and knives are furnished to all the provinces of the north and east. Silver is not found in Siam. As regards gold, this metal is found in many places, but the mines at Bang Tapan on the west coast are said to contain the purest gold in the

country. They have been worked by the natives by simply turning over the ground, the gold being found in the shape of nuggets. When nuggets over a certain size were found, the miners were obliged to hand them over to the Government, but they were paid for the same according to a tariff fixed by the authorities. A syndicate of foreigners has been formed, with a concession from the king, for working these mines, and have now a number of workmen employed, the prospects for rich developments being good. The quartz mines of Muang Krabin, although productive, were declared unprofitable to the Government. Experienced engineers from Australia, mining machinery of recent invention, immense upright pumps and other hydraulic machinery, and a narrow gauge railroad with rolling stock for the conveyance of the product, had been procured for the working of the mine, but the organiser of the great scheme having been decapitated for alleged treason, the whole of the plant is lying idle. The royal metal of Siam is mostly manufactured into vases, teapots, betel boxes, and other articles, which it is the custom of the kings of Siam to present to subjects upon their elevation to high rank in the peerage of the kingdom. They are looked upon in a sense as insignia of their exalted rank, the shape and style of the set denoting the standing of the beneficiary. It is impossible to procure statistics concerning the output of the mines. Iron of good quality is found in the eastern provinces, but it is worked in a very crude and primitive manner. Foundries are unknown. A hole or pit having been dug close to the mountain, the miner collects and piles up his ore, which he smelts with charcoal. The molten metal is deposited in a cavity prepared for its reception, and when cold the product is carried home. There a fire is prepared which is kept alive by a bellows, made of two trunks of hollow trees buried in the ground, and having two long sticks as handles. A child works the bellows while husband and wife or son hammer the iron into shape. The knife, cutlass, spear, or agricultural implement produced by this combined labour finds a ready sale throughout the north of Siam, and although the workmanship is poor, it suits the requirements of that section. The locality of the mines preclude shipments to Bangkok, as it would have to be conveyed to the river on elephants, a method of conveyance too expensive for the commodity. Tin is found in profusion in the Malayan peninsula, and is worked by Chinamen. It is generally exported direct to Singapore from the locality in which it is mined. Tin is also found in Eastern Siam to a limited extent, but none of it finds its way to the capital. Copper is found in certain localities, especially in the eastern provinces—Champasak, Petchaboon, and Löm. In the former province, on the Makong River, there is a place where the natives procure the finest metal, of which they make a coin that passes current in that locality. It is about two inches in length, a quarter of an inch in breadth, and shaped like a canoe. The province adjoining that has an iron coin of the same shape, but larger in size. Virgin copper is held in great esteem by many for certain qualities it is supposed to possess when employed as an agent in transmitting metals. Without it as a basis, the native alchemists claim that gold cannot be obtained. Coal is found on the coast and in the interior, but cannot be utilised. Limestone is brought to Bangkok from the interior; the lime is mixed with turmeric, and is used to a large extent by the Siamese in combination with the betel-nut and *seri* (pepper leaf). Precious stones come principally from the province of Chantibun, rubies, sapphires, topaz, asterias, and other stones being found in that district. The diamond is unknown as a native stone. The sapphire mines to the south of Chantibun, to which thousands of Burmese flocked a few years ago, have been exhausted.

COTTON CULTIVATION IN MEXICO.

The *Courrier du Mexique* says that cotton is one of the most important textiles of Mexico. It is grown in the States of Tamaulipas, Vera Cruz, Yucatan, Sonora, Sinaloa, Jalisco, Colima, Michoacan, Guerrero, Oaxaca, Chiapas, Coahuila, Durango, Chihuahua, and in Lower California. The longest fibre is that of the Acapulco district (State of Guerrero), which attains a length of 37 millimetres, and the shortest is that of the yellow cotton known as *coyote*, which is found in the Department of Simojovel, only measuring $26\frac{1}{2}$ millimetres. Commencing with the Gulf States, and taking the State of Tamaulipas, as a point of departure, it will be found that very little cotton is produced in the northern and southern districts, that is to say, in the districts of Matamoros and Tampico; but in the district of Tula a soil is found in every way suitable for its cultivation. Experiments which have been made in the central districts have been very successful. According to official reports published by the Minister of Finance, the production of cotton in the State of Tamaulipas, in the year 1878, amounted to only 1,108,000 lbs.; but according to more recent returns the production may be estimated at 2,030,000 lbs., and the annual value at 190,000 Mexican dollars. It is stated that a circumstance favourable to the development of the cotton industry in Tamaulipas is its vicinity to the United States. This State borders upon Texas, and although the latter is essentially a cotton district, its production is not always sufficient to meet the demands of the American markets. In Vera Cruz the soil and atmospheric conditions are eminently adapted to the cultivation of cotton, and the superiority of its production has been well established. The cotton districts of the State of Vera Cruz are Chicontepec Ozuluama, Tantoyuca, Tuxpan, Coatepec, Cordoba, Vera Cruz, Tuxtlas, Cosamaloapam, Misantla, Papantla, and Minatilban. The most important of

these districts is Cosamaloapam. The districts of Huatusco and Jalapa produce, in about equal quantities, white and yellow cotton, the latter being known as *coyote*. The ground is prepared in January and February, and maize is sown in May, the cotton seed being sown in September; the plants begin to shoot at the end of five or six days. The land measure commonly used in Vera Cruz is the *cuartilla*, which is equivalent to an area of 25,000 square varas (the square vara being equal to 86 square yards). The cost of cultivation of a *cuartilla* is 105 dollars, and each *cuartilla*, taking good and bad years together, yields, on an average, 5,000 lbs. of cotton, valued at 200 dollars, the grower, therefore, realising a profit of 95 dollars. The annual production of cotton in the State of Vera Cruz amounts to 41,000,000 lbs., representing a value of nearly 200,000 Mexican dollars. The annual production of the four most important cotton-growing districts is as follows:—Cosamaloapam, 5,630,000 lbs.; Tantoyuca, 4,796,000 lbs.; Tuxpam, 4,818,000 lbs.; and Tuxtla, 4,554,000 lbs. About ten years ago, according to a report published by M. Busto, Minister of Finance, the annual cotton production of Vera Cruz was given as 23,232,000 lbs. The States of Campêche, Tabasco, and Yucatan cultivate cotton on a very small scale, although, in the former especially, the soil is eminently suited to its cultivation. In the State of Yucatan, the northern districts, which are not subject to the inroads of the Indians, are much too dry for the cultivation of cotton, while the south, which is well wooded, offers unusual facilities for this cultivation. *Le Courrier du Mexique*, in conclusion, states that the cotton zone of the Gulf produces annually more than 44,000,000 lbs. of cotton, representing an approximate value of 4,840,000 dollars.

Correspondence.

SALT.

Appended to the valuable paper of Mr. P. L. Simmonds is an estimate (p. 151) of the consumption of salt per head. Where there is a free supply of salt, as in England, the consumption may be considered to have reached a maximum. Nevertheless, great variations in consumption will take place. For instance, the consumption in England probably included cattle, which are large consumers of salt. Then, according to climate or local circumstances, there is consumption for butter-making, curing pork, fish, &c. In some countries the actual consumption is partly provided by smuggling.

HYDE CLARKE.

General Notes.

RAILWAY DEVELOPMENT IN BRAZIL.—The *Economiste Français* says that, according to official returns recently published, the length of railway line in Brazil at present amounts to 13,480 kilometres distributed as follows:—Railways working, 8,573 kilometres; in course of construction, 1,310; projected, 3,597; making a total of 13,480 kilometres. The lines in the various provinces are sub-divided as follows:—State lines, 4,624 kilometres: lines whose interest is guaranteed by the State, 2,797; provincial lines, 245; lines whose interest is guaranteed by the provinces, 2,805; lines whose interest is not guaranteed, 2,917; and urban and suburban lines, 92 kilometres. The opening of the first railway in Brazil dates from the year 1858. In 1887 the guaranteed lines carried 6,434,806 passengers, 843,577 tons of merchandise, and 34,445,625 animals, the receipts from which amounted to 37,156,000 fr. (£1,486,000), while the expenses amounted to 26,380,000 fr. (£1,055,000). The net receipts therefore amounted to 10,776,000 fr. (£431,000).

BASIC, OR THOMAS-GILCHRIST PROCESS.—The total make of steel and ingot iron from phosphoric pig during the twelve months ending 31st December, 1888, amounts to 1,953,234 tons, being an increase over the make for the previous twelve months of about 248,753 tons, and making the total production of basic steel to this date 8,570,000 tons. It will be noticed that of the above-mentioned make of 1,953,234 tons, no fewer than 1,493,032 tons were ingot iron, containing under 17 per cent. of carbon. The make of the various countries for the twelve months ending 31st October, 1887, and 31st December, 1888, respectively, are as follows:—

	1887.		1888.	
	Total tons.	With under 17 per cent. carbon.	Total tons.	With under 17 per cent. carbon.
England	364,526	233,358	403,594	276,476
Germany, Luxemburg, & Austria	1,102,496	826,609	1,276,070	1,026,022
France	176,500	123,049	222,333	158,223
Belgium and other countries	60,959	39,716	46,237	32,300
Totals......	1,704,481	1,222,732	1,953,234	1,493,032

With this 1,953,234 tons of basic steel were produced some 600,000 tons of slag (containing about 36 per cent. of phosphate of lime), most of which was used as a fertiliser.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings at Eight o'clock :—

FEBRUARY 27.—"The Irish Lace Industry." By ALAN S. COLE.

MARCH 6.—"Arc Lamps and their Mechanism." By Prof. SILVANUS P. THOMPSON.

MARCH 13.—"Aluminium and its Manufacture on the Deville-Castner Process." By WILLIAM ANDERSON, M.Inst.C.E. Prof. SIR HENRY ROSCOE, F.R.S., will preside.

MARCH 20.—"Motor Trials of the Society of Arts, 1888." By Prof. A. B. W. KENNEDY, F.R.S.

MARCH 27.—"The Sanitary Functions of County Councils." By SIR DOUGLAS GALTON, K.C.B.

FOREIGN AND COLONIAL SECTION.

Tuesday evenings, at Eight o'clock :—

MARCH 26.—"Borneo." By ROBERT PRITCHETT.

APRIL 2.—"The Argentine Republic." By F. K. SMYTHIES.

APPLIED ART SECTION.

Tuesday evenings, at Eight o'clock :—

FEBRUARY 26.—"English Bookbinding in the Reign of Henry VIII." By W. H. J. WEALE. E. MAUNDE THOMPSON, D.C.L., F.S.A., Principal Librarian to the British Museum, will preside.

MARCH 19.—"The Art of the Jeweller." By CARLO GIULIANO. SIR GEORGE BIRDWOOD, K.C.I.E., C.S.I., will preside.

APRIL 9.—

MAY 14.—"Venetian Glass." By DR. SALVIATI

INDIAN SECTION.

Friday evenings, at Eight o'clock :—

MARCH 8.—"The Present Condition and the Prospects of Indian Agriculture." By PROF. ROBERT WALLACE. The DUKE OF BUCKINGHAM, G.C.S.I., will preside.

MARCH 29.—"The Progress of the Railways and Trade of India." By SIR JULAND DANVERS, K.C.S.I. SIR GEORGE BRUCE, P.Inst.C.E., will preside.

MAY 3.—"The Karun as a Trade Route." By MAJOR-GENERAL SIR R. MURDOCH SMITH, K.C.M.G.

MAY 24.—"Indian Wheats." By JOHN McDOUGALL.

CANTOR LECTURES.

The following course of Cantor Lectures will be delivered on Monday evenings at Eight o'clock :—

WALTER CRANE, "The Decoration and Illustration of Books." Three Lectures. March 4, 11, 18.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, FEB. 25 ... Geographical, University of London, Burlington-gardens, W., 8½ p.m. Capt. Vangele, "Explorations on the Welle-Mobangi River, from the Congo;" with notes by Col. Sir Francis de Winton.
British Architects, 9, Conduit-street, W., 8 p.m.
Actuaries, The Quadrangle, King's College, W.C., 7 p.m.
Medical, 11, Chandos-street, W., 8½ p.m.
London Institution, Finsbury-circus, E.C., 5 p.m. Mr. C. V. Boys, "Soap Bubbles, and what may be shown with them."

TUESDAY, FEB. 26 ... SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Applied Art Section. Mr. W. H. J. Weale, "English Bookbinding in the Reign of Henry VIII."
Royal Institution, Albemarle-street, W., 3 p.m. Dr. G. J. Romanes, "Before and After Darwin." II. "Evolution." (Lecture VI.)
Medical and Chirurgical, 53, Berners-street, Oxford-street, W., 8½ p.m.
Civil Engineers, 25, Great George-street, S.W., 8 p.m. Adjourned discussion on Mr. Gisbert Kapp's paper, "Alternate-Current Machinery."
Anthropological, 3, Hanover-square, W., 8½ p.m. 1. Mr. Francis Galton, "Exhibition of a new Instrument for Testing the Delicacy of Perception of Differences of Tint." 2. Major C. R. Conder, "The Early Races of Western Asia."

WEDNESDAY, FEB. 27...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. Alan S. Cole, "The Irish Lace Industry."
Cymmrodorion, 27, Chancery-lane, W.C., 8 p.m. Mr. H. Owen, "Giraldus Cambrensis."

THURSDAY, FEB. 28...Royal, Burlington-house, W., 4½ p.m.
Antiquaries, Burlington-house, W., 8½ p.m.
London Institution, Finsbury-circus, E.C., 6 p.m. Mr. Carl Armbruster, "Modern Composers of Classical Song." I. Franz Liszt, Johannes Brahms, and others.
Society for the Encouragement of Fine Arts, 9, Conduit-street, W., 8 p.m. Mr. C. Pfoundes, "The Art of Old Japan, Religious and Classical Literary Influence, with Native Illustrations."
Parkes Museum of Hygiene, 74A, Margaret-street, W., 5 p.m. Colonel W. Hope, "The Metropolitan Sewage Question."
Royal Institution, Albemarle-street, W., 3 p.m. Dr. Sidney Martin, "The Venom of Serpents and allied Poisons." (Lecture II.)
Electrical Engineers, 25, Great George-street, S.W., 8 p.m.

FRIDAY, MARCH 1. ..United Service Institute, Whitehall-yard, 3 p.m.
Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting, 9 p.m. Mr. Edmund Gosse, "Leigh Hunt."
Geologists' Association, University College, W.C., 8 p.m.
Philological, University College, W.C., 8 p.m. Dr. Whitley Stokes, "A Recent Edition of the Passions and Homilies in the Lebar Brece."

SATURDAY, MARCH 2...Royal Institution, Albemarle-street, W., 3 p.m. Lord Rayleigh, "Experimental Optics." (Lecture II.)

CORRECTION.—page 254, col. 2, line 16 from bottom, for 223,600,000 tons read 233,600 tons.

Journal of the Society of Arts.

No. 1,893. Vol. XXXVII.

FRIDAY, MARCH 1, 1889.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

PRIZES FOR ART-WORKMEN.

Prizes are offered to Art-workmen in the following classes :—

I.—Pottery (including Porcelain and Earthenware).

1. The Body, any material.
   - *a.* Thrown, not shaved, first prize, £5; second prize, £2.
   - *b.* Shaved or turned, first prize, £5; second prize, £2.
2. Decoration.
   - *a.* Modelled and glazed, first prize, £10; second prize, £5; third prize, £3.
   - *b.* Painted under glaze, first prize, £10; second prize, £5; third prize, £3.
   - *c.* Enamel on the glaze, first prize, £10, second prize, £5; third prize, £3.
3. Stone salt-glazed ware.
   - *a.* Plain; incised and glazed, first prize, £10; second prize, £3; third prize, £3.
   - *b.* Coloured or otherwise decorated, first prize, £10; second prize, £3; third prize, £3.

The Art-workman must have designed the body of the pot as well as have executed the decoration.

All the specimens of pottery sent in for competition must be dated on the clay.

II.—Stone Carving.

First prize, £25; second prize, £15; third prize, £10; fourth prize, £5.

The capital of a column, with square, circular, or octagonal abacus, not to exceed twelve inches in width.

III.—Wrought-Iron Grilles.

First prize, £25; second prize, £15; third prize, £5.

A grille measuring not less than three feet superficial, nor more than five feet superficial.

The object for which the grille is intended must be stated—whether for a protective purpose, for the outside of a window, for a street-door panel, or for indoor use as a window screen, coil case, ventilator, &c.

IV.—Goldsmiths' and Silversmiths' Work.

[Prizes presented by the Goldsmiths' Company.]

A cup or sugar basin of beaten silver, chased or otherwise, made within the year 1888. First prize, £20; second prize, £5.

A pendant or brooch, or locket of gold without gems. First prize, £20; second prize, £5.

All articles for competition must be sent in to the Society's House on or before Tuesday, April 23rd, 1889.

The conditions under which these prizes are offered have appeared in previous numbers of the *Journal.** They can also be obtained on application to the Secretary.

Proceedings of the Society.

FOREIGN & COLONIAL SECTION.

Tuesday, February 19, 1889; the Earl of Dundonald, in the chair.

The paper read was—

SLAVERY IN ITS RELATION TO TRADE IN TROPICAL AFRICA.

By Commander V. Lovett Cameron, C.B., R.N.

The question to which I am now devoting nearly all the time I can possibly manage to spare is that of slavery in Africa; but I find at times that people seem to have an idea that if slavery is done away with too quickly, the commercial interest of this country will in some degree suffer. Before I speak absolutely about Africa, I would say that one of the stock

* See *Journal*, June 15.

arguments which we have heard on the subject of the emancipation of slaves in the West Indies may be somewhat met by an argument on the other side. People say that the comparatively hurried emancipation of slaves in the West Indies caused diminution in trade, the ruin of the planters, and other evils. The answer to this argument is that at the time the emancipation of slaves took place, a vast majority of the owners of landed property in the West Indies were living in England or in Europe, and that when this great effort was made by the British nation to free itself from the disgrace of slavery, most of the estates were managed by attorneys or agents. It is said that the people who were living in Europe thought they had a lot of ready money, and were able to live a little more easily, and that the managers of the estates out in the West Indies thought that if they held out a certain time against giving the wages which they thought the liberated slaves would demand, they might bring them to their own terms. Whilst the ready money which was granted by the English nation lasted, it was comparatively easy to hold out, but when the time came when that money had been spent, and they came to the freed slaves for labour, many of these freed slaves, who had refused to labour at utterly inadequate pay, as they thought, had found on the unoccupied ground on the different islands the means to support themselves, and gain what they considered necessary for their living, and therefore they were not ready to come back to labour on the estates for wages. That is an old story, but here is a more modern example. It is only this last year that when, in the great empire of the Brazils, the slaves were freed—I am told this by a gentleman from Brazil, who was there at the time—there was a great deal of anxiety lest the exceptionally abundant coffee crop should be wasted because there would not be labour to gather it. So far from that being the case, although a certain number of liberated slaves refused to work for wages, and went away on the waste lands to get their own living, still there was a sufficient number remaining to supply the demand for labour, and they worked very much better for wages, so that they were able to do all the work necessary for gathering this specially abundant crop. This shows us that slavery can be abolished without upsetting commercial relations.

This large map of Africa tells us something of how slavery goes on in that vast country. All the lighter-coloured pink shows where hunting for slaves is now going on; but the darker colours show where, only twelve years ago, when I came back from my journey across Africa, whole peoples had been swept away. I will try to go round the continent of Africa and tell you how far slavery has gone, and how far commerce has gone on with it. We have had with the West Coast of Africa a trade which has lasted since the days of the Tudors. In the old days our ships used to go out from Liverpool or Bristol, taking a cargo down to the West Coast, and then going across to the West Indies with a cargo of slaves, return loaded with sugar and tobacco from the West India Islands and the colony of Virginia. That trade existed for centuries, but it increased in a comparatively slow manner, until the first great blow to the transport of slaves to the West Indies was struck, in the beginning of this century, by this country fighting against the slave trade by sea. The next step was the liberation of the slaves in the West India Islands, and then came the liberation of slaves in America in the great war between the North and South. Since that time there has been the liberation of slaves in Cuba, brought about mainly by the good sense of those people who were born in Cuba, not by the people of Spain itself. We have found that with the cessation of the demand there have been fewer slaves brought down to the coast for sale. But instead of the cessation of the demand for slaves having reduced our commerce with the West Coast of Africa, our trade with the coast of Africa since the slave trade was stopped by the strict blockade under Commodore Wilmot and Admiral Sir Geoffrey Hornby has grown by leaps and bounds; and though it is only a little over 30 years ago since regular steamers were sent to the West Coast, from Liverpool and from Hamburg, there are now over 150 steamers every year going down the West Coast of Africa. It was only in 1851 that we attacked a great nest of slave dealers at Lagos, and in 1861 Lagos was made a British colony. Up to that time there had been no trade at Lagos whatever, except the trade in slaves, but last year the trade had grown to such an extent that the import of goods was £357,821, and the export £538,980.

In most cases we look upon a country that sends goods of a greater value to us as draining us of some of our cash, but as Lagos imports no cash, these £538,000 odd have been

paid for practically by the £357,000 of imports, and the difference of the two is a profit really to our English merchants, and to their competitors, the Germans and others, who trade there; but the major portion of the difference of £180,000 is really the profit of the English merchant. That is at a place that only 38 years ago was not of any value to us for legitimate commerce; we have taken it out of the hands of the slave dealers, and we have developed it under English rule into a most prosperous colony.

We hear a good deal of talk about Sierra Leone and the Gambia and Liberia. Liberia is not English, but it is under somewhat the same conditions. These places are not going on so well as they ought, and are not paying perhaps so well as they ought. They do pay us directly or indirectly, all of them, but it is not because there is no slavery there that they are not so prosperous as they ought to be; it is because, without true judgment in all cases, the people who had been slaves have been admitted to absolute freedom of political rights, which is a very different thing from the question of personal freedom; and to a certain extent in Gambia, Sierra Leone, and still more in the Republic of Liberia, the people have not altogether been able to wield to their own or their customers' best advantage the rights which have been given to them. But Sierra Leone is a place which is of great advantage to England, as being one of our great strategical points in the defence of the Empire. It is a place whose commercial importance is growing largely every day. It would grow faster if it were not that so many of the people who have been brought to Sierra Leone, and have settled there, were freed slaves, and their descendants have inherited the idea that the work of cultivating the ground is only fit for slaves, and as they are free they ought to embark in petty trade. Hence, in Sierra Leone, the great value of which is as an agricultural country, the people show rather the genius and skill of traders, instead of developing its almost unrivalled agricultural capabilities. Moreover, up the Rokelle river, where, owing to the supineness of the British Government, we have allowed the French and other nations to beat us to a great extent in commercial development, we have also allowed Samadu and other native chiefs, who bring Mahomedanism and slavery with them, to spread down from the interior, and thus we have lost not only a chance of spreading freedom up to the sources of the Niger, but also lost a chance of developing the most paying trade. The house that does almost all the trade now is a Marseilles house. The French traders have no prejudice about slavery like we English people, and, in consequence, they have supplied guns and powder, and other things, by which short-sighted policy they may get a greater immediate return; but it will be detrimental to trade in the future.

South of Liberia we come to the Kroo coast. Kroo people have always been looked upon as a hardy and independent race, and so they are; but we must also remark that these Kroo people, if it had not been that they were able (by the guns and the powder with which they get paid for their work down in the factories of the Bight of Benin) to prey on the interior people and make slaves of them. These slaves, who are afterwards marked with the Kroo mark and very often shipped as true Kroo boys, would not be able to hold their own country and to keep white people out of it, and thus prevent the development of a very rich country. At present the Kroo coast gives a small quota of trade to a few trading ships from Bristol, and also supplies labour for the gold mines on the Gold Coast, and for the factories down south. But it does not, as it ought, cultivate vegetable produce, because its inhabitants are able to get enough pay down the coast as labourers, and also are able to do a very good business by making slaves in the interior whom they mark as Kroo men, who become nominally free, but who are subject to the peculiar Kroo law. When a man goes away down the coast for a year or two, he has on his return to pay the greater part of his wages into the village fund, and those who have been made slaves have to pay a very much larger proportion than the people who are actually true born Kroo boys.

Coming to the Gold Coast, slavery has been practically abolished by the British Government, even that system of pawns which is the most defensible form of slavery, under which men borrow money on the strength of working for one, two, or three years, or whatever the time be, according to the sum they have borrowed, being illegal. But notwithstanding that, there is practically a great deal of slavery, owing to the native customs. And we find again that the people who have been used to slavery have the same objection as at Sierra Leone, and at other places, to manual labour. Day by day this

feeling, however, is growing less, and people are more ready to work for wages. Education also is advancing; and although all British merchants may not think that the educated native of the Gold Coast is the most desirable correspondent, still at the same time education and freedom are progressing, and according to my latest news from the Gold Coast, there is a decided improvement in the state of things, the people being more ready to work for wages, and also that there is more honesty amongst the so-called educated classes.

Between Lagos and the Gold Coast there is a small strip of coast, including Dahomey and Whyda, that was entirely a slave place until the transatlantic slave trade was stopped. Now our ships, and others, get a fair amount of trade from Whyda and from two places called Quetta and Popo. When I came up this coast, Quetta was an English port, and Popo, too, was under English influence. Quetta is still English, but Popo is now German. I want to give the following statement in all carefulness, and I will not say it is absolutely true, but it is the report of native traders at Popo to an English merchant at Liverpool. I should like, before it is stated as a certainty, that it should be well authenticated, but these three or four native merchants at Popo, and Quetta, write to say that the Germans, now they have Popo, allow Salaga merchants from the interior, to sell slaves right down close to the sea coast to the native people of Popo, and that, in consequence, the Quetta merchants do not get the trade they did. These people did not argue that we should permit slavery in Quetta, but they ask us to stop it in Popo, because this permission of the slave trade diminishes the bulk of all real trade, that Popo now practically has the trade of the two places, though that it is not half of what was the trade of Quetta and Popo before the Germans, as they say, allowed slavery at the latter place.

Further south we come to the Congo Free State, where the slavery question is a very thorny one. It is four years only since the Congo Free State was established. I remember speaking here just when it was established—my friend, Mr. Hyde Clarke, being in the chair—and dealing with all that had been said of and intended for that State; but, unfortunately, in these four years I cannot help thinking that although the intentions of the King of the Belgians have been perfectly good, and that M. Janssen, who has lately come home from being the Governor-General, was also honest in his endeavours to arrest slavery, that in the lower classes of the officials of the Congo Free State there has been wanting that spirit of antagonism to slavery such as we feel here in England. There was Dr. Summers, a missionary, stationed for a long time at a place called Luluaburg. He was coming away because he was made so uncomfortable owing to having spoken against slavery, but he died before he could leave. He stated that he saw one caravan commanded by officials of the Congo Free State, who allowed their men to engage in slavery because the wages that they could afford to give were not sufficient to pay them. In that Congo State, four years ago, it was said that every flag was to be free; in this last January's *Blackwood* it is said that the only flag now to be seen is the blue flag with the gold star of the Congo Free State, and that its territory extends right up to the Tanganyika. In the Congo Free State many countries are included in which no official of the State has ever been, and it is here that the greatest depopulation has taken place on account of slavery. I hear that the Congo Free State naturally wishes to get a railway from Stanley Pools to the coast, and they want to show there is traffic to pay for that railway. In the country up towards Stanley Falls they are ready to buy ivory and to send it down the river, instead of by the old way across to Zanzibar. I think this cannot be disputed for it is reported by different eye witnesses. There are some people who tell me things who say their names must not be mentioned, and therefore I have to take the responsibility of quoting them on my own shoulders. There is no doubt when the ivory trade went to Zanzibar, for the carriage of it a certain number of men were wanted, and therefore when slaves were obtained by the destroying of villages, the men were saved in order to act as porters. Now when there is an easier transit, the men, as Cardinal Lavigerie told us on the 31st July, are all slaughtered.

There is no doubt this is the case, as it has been confirmed by a missionary, Mr. Brooks, who was on the Congo. I heard that Muingi Somai, who came up to supply porters to Major Barttelot and Mr. Jameson, had destroyed villages; most of the inhabitants were absolutely killed, a few made prisoners, and a few suffered to escape. Those few who were made prisoners were ransomed for ivory, and the few that escaped formed a new village. But

in a short time the same game was carried on, and it has come to this, in fact, that instead of making slaves for porters, they now, being able to get rid of the ivory easily, only take the women and children. The children are brought up for domestic slaves, and as for the women, it is to the grandeur of a man that he shall have a great number of wives. Unfortunately, the number of people who have been attracted up into the same country, over which the Congo Free State has not pretended to exercise any real jurisdiction beyond the Stanley Falls, although it claims authority over this enormous district, is far in excess of those who can make a living by ivory.

Further south, in Loanda, the Portuguese have abolished slavery for some time, but they still maintain what is almost as bad, viz., a system of apprenticeship of the people, whom they call *libertos*. There is a great deal of work done in Portuguese settlements by means of these *libertos*. M. Chatelain, another missionary from whom I heard, says there are numbers of slaves still brought down to the interior of the province of Angola. Some are retained in the interior of the province, where no legal authority exists, and others come down to the coast, where they are frequently made into *libertos;* they get something like two dollars a year and some clothing, and just enough food to keep them alive.

There is another branch of trade from Benguela. There is no slave trade at Benguela itself, now, but there is a trade in beeswax, ivory, and india-rubber. In Kerongo's territory I found the first trade caravan. There a man goes away as porter for three years; he is paid about 12 dollars wages, three yards of cloth, and they obtain still as many slaves as they can. This caravan came back with only a small amount of ivory, but about 3,000 slaves. When the ivory is brought down to Bihe it is sent to Benguela, where it is bought by the Portuguese and is carried between Benguela and Bihe by the intermediate tribes. The survivors of the slaves are sent on to the Victoria Falls and Zambesi. That is trade and slavery.

Further south there is the Cape. Mr. Mackenzie, once our Commissioner in Bechuanaland, a man who speaks with more authority on the subject than any living man, divides Southern Africa into two parties: the English-speaking people and the better class of Dutch-speaking people, who are, like the Northerners in the Civil War in America, entirely abolitionists, and form one side. Then there are the inferior class of Dutch people, who are for slavery. We must remember also that there is another great crime in Africa—the drink trade, and the same people who would go in for oppressing the native races, and forcing them into actual slavery or apprenticeship—which is much the same—are the same people who are the brandy growers near the Cape, and who force on the Cape Legislature free trade in brandy.

North of the Cape we come to the Portuguese territory on the east coast, and we find that at Kilimani there are no exports at the present moment, but slaves are brought down to the Portuguese planters from near Lake Nyassa. Tete and Sena are places to which slaves are drawn from the interior native countries. But the Moslem negroid tribes living inside the Portuguese coast line raid round the south end of the Nyassa, across the Zambesi, up to Lake Bangweolo, the country where Livingstone died, and they sweep slaves down to this coast, where they are sent as *émigrés libres* to the French colonies of Réunion and Bourbon. For some time that trade was stopped. Our Government in India allowed coolies to go there under the same regulations as they go to British colonies; but as the Frenchmen would not allow that, our Government very properly stopped the export of coolies to these islands, and now that the coolies cannot go there any longer, the creoles of Réunion and Bourbon have started again this trade in *émigrés libres*.

Further north we come to the Zanzibar coast, where an export goes on to Arabia and Persia. Arabia and Persia have a certain trade with Zanzibar besides slaves, though it is very small. The biggest trade is with India and British subjects, and if we could stop the slave trade altogether, there is no doubt that the people who now go to hunt for slaves might be collecting india-rubber, digging for copal, growing coffee, and doing many things which would give us absolute value for English goods. After Sir Bartle Frere's mission, in 1872, which I accompanied, Sir John Kirk passed a stringent treaty, and it did a very great deal of good in stopping the export of slaves, and there was enormous growth of legitimate trade with British India. In every little port along the coast there were Indian dhows or Zanzibar dhows flying the British flag under English protection. When that treaty was passed, a great many of the educated men set themselves, under the

orders of their Sultan, to stop slaves coming down to the coast. But this was a very small part of the Zanzibar trade. It was all that we could do as long as we confined ourselves to operations on the sea coast; but the traffic exists on the trade routes, stretching out into the interior in every direction, and is worked by traders from Zanzibar, usually called Arabs—and by the Wanyamwesi. The Wanyamwesi themselves are great allies of the traders, and are the main force that the Arab traders use in those awful slave hunts that go on to the west of the lakes. Mrs. Hore, the wife of Captain Hore, who was eleven years on the Tanganyika, and who was up there five years herself, says that the slave trade is going on in Africa ten times worse than in Livingstone's time. I have not the exact words, but she says that if you sealed up Africa altogether, and never allowed a single slave to be exported, the ordinary slave trade of Africa would support itself, and that is absolutely true.

I saw this myself, when I was travelling down along this slave trade route with a slave caravan. Where the traders I was travelling with were not strong enough to steal, they paid for their food and maintenance by selling the slaves they were carrying with them. They made the slave caravan pay for itself. If they had 300 or 400 slaves to start with, one day they would sell two, and another three, and so on. When they actually came to the end of their journey they found that though they had gone into Central Africa on the idea that they were going up to get slaves for a few cartridges, when they came back it was found that there would be very few slaves left to pay them for their two or three years' work, so that there was a very small profit after all.

It is now about fifty years ago since Arab traders first began to work into Central Africa. You must remember the Portuguese, after they rounded the Cape, swept up the whole coast. I remember up at Brava, a beautiful little look-out place, it was an old Portuguese tower, and so at Merka and Pemba, and all these places there are remains of old Portuguese buildings. It is rather over a century ago, since the Iman of Muscat re-established the Arab authority down to Cape Delgado. From the days of Solomon, I believe, slaves have been exported from the east coast of Africa, but it was a comparatively small traffic. It is from 1778, or thereabouts, when they began their new trade. First of, all the interior tribes brought down ivory and a few slaves that they hunted for in their immediate neighbourhood, and it was not until about 1830 that any Arab trader in modern times got further than the territory of Ugogo. In 1837 or 1838 the first traders, pioneered by an Indian merchant, established themselves at Unyanyembe, and it was another ten years before they got to Tanganyika. Then the trade extended to the Kazembi country, and one of the Arabs managed to get down to Benguela and back again. Livingstone and I both met this man. When we came up to Nyangwe there was very little slavery there. There were a certain amount of Arab traders, but they did not carry on the trade as they have done since. When I was at Mpwapwa the whole of the arms in the place were four old flint-lock muskets. Now there is a church missionary station, and the people have some 500 or 600 rifles almost of the latest date; in fact, you can buy Winchester rifles cheaply at Ujiji and Nyangwe. But the slave trade was then subsidiary to the ivory trade. The people mainly made slaves that they might get porters for their ivory; but that has in the last twelve years changed entirely. When people heard of getting a tusk for a copper bracelet or 50 or 60 cowries, there was a rush for ivory. But they found naturally the price of ivory went up, and they could not buy it; in fact, it was the first few people who swept away the great stock of ivory that had been accumulating. Then they set themselves to develop the slave trade, which was the only thing they thought would pay, and the way they carried it out was to shoot the men and carry away the women and children. When I went up some years ago, I am happy to say the name of a British consul was a name to conjure with, but I am afraid this is not the case now. From Colonel Hamerton down to Sir John Kirk they had always a great power for good in Zanzibar, and every man who went from there was afraid of being reported to the English Consul. Now our power in Zanzibar, I am afraid, is not very much, and these fellows have found it out, and even when Mr. Thompson was at Lake Tanganyika he crossed the lake in a boat loaded with slaves, and heard of a boat-load of 80 odd slaves being drowned, and very little remark being made about it. When I was at Lake Tanganyika such a thing as a boat-load of slaves crossing the lake was not known. Further on

my way to Nyangwe, Arabs who had waited for me to come up, in order to get the protection of my caravan while travelling, got into trouble. I would not have anything to do with them because they made slaves. The first day after peace was restored, before we started, in order to prevent difficulties I allowed a certain number of these slaves to have some ransom paid for them, because it was very difficult to know who was in the wrong or who was in the right; but a day or two afterwards, finding slaves still being captured, I was able, simply by saying that I was an Englishman, and that news of it would go to the English Consul at Zanzibar, and that the slave stealers would get into trouble, to get those slaves liberated.

The African Lakes Company in Nyassa has been working for years to prove that legitimate trade would beat slavery. It has proved that legitimate trade can be a success if slavery is stopped, and they thought this could be done entirely by moral force. But, after a time, the slavers began to run their cargoes of slaves across the lake right under the nose of their steam launch, and now they prevent the people of the African Lakes Company making their way to Tanganyika, and offer them every opposition. I believe if we had kept our old prestige at Zanzibar, the African Lakes Company would have been able to do all they intended from the first—to do all things peaceably. But it is a proof that, although legitimate trade is one of the great factors against slavery, you need other things as well as legitimate trade. You need moral force, the moral force of England that her people will have nothing to do with slavery; and you need sufficient physical force to prevent the low class of slaver setting himself up in opposition to you. If those men had seen sufficient force, if there was a real power on the lake instead of six, eight, ten, or twenty white men, they would never have dared to attack the African Lakes Company; and I believe it will be found that in time we can carry on a trade there. Consul O'Neill, of Mozambique, said he could think of nothing better than for a young man to go out from Lake Nyassa collecting ivory instead of slave dealing, because he would get a profit out of it. That was possible while the prestige of England was what it used to be, but now if a young white man went out from Nyassa to collect ivory, when he had got 40 or 50 or 100 tusks, some of these slave dealers would sweep down on him, take the tusks, shoot him, and all his followers would be made slaves. That is the relation at present between legitimate trade and the slave trade in the east.

I have taken you now nearly all round Africa, and there remains only the trade through Suakim to Arabia. Before all the troubles in the Soudan, there was a great trade through Suakim to Arabia with the tribes —who I hope now are again going to enter into peaceable relations with us—between Khartoum and Suakim. They used to bring down senna, gum, ostrich feathers, ivory, and many other things to Suakim. Now we scarcely hear of any of these various articles of legitimate commerce going to the coast; we find that more slaves go across to Jedda from the neighbourhood of Suakim than was ever known before. True enough, we have a treaty with Turkey that she should not import slaves, but whilst the Sultan is the Sultan, and whilst the profits of the trade are what they are, the treaty of the Sultan of Turkey against slavery is all nonsense. If we can enter into relations with these tribes again, we may again bring valuable things from the Nile valleys.

Gessi, Lupton, all these men managed to free slaves. They managed by legitimate commerce to prove that the Equatorial Provinces south of the Bahr of Gazel, the district that Emin has now, would pay all the Government expenses, and also send a considerable revenue back into Cairo. Now that we have stopped the importation of slaves into Egypt, Tripoli, which is a Turkish province, imports slaves largely. We have simply diverted them from going to Dongola; some, instead of going across the forty days' march from Darfour to Dongola, are now taken on the line of oases across to Tripoli, and the loss of people who die on the desert march is ten times greater than all of those who were taken to Dongola. Nachtigal tells us the trade to Darfour was very great. He says there was gold and ivory too, but in the first place there were slaves, and since the troubles have arisen you must not put it all down to the Mahdi, but also to the dislike of the native races to the Turkish people in Egypt. Scarcely anything goes across the Sahara from Darfour now but slaves, and it is from Tripoli that a great amount of the arms and ammunition come which are used by the Dervishes. All across this tract of the negroid tribes, which lies north of the Jung, there is also a trade in slaves even to the interior of Algeria and Morocco. The slaves taken to Morocco are taken from the borders of the

French colony of Senegambia. That is French business.

The question of slavery in the interior of Algeria is also a French business. The same in Tunis. As for Tuat and Fez, they should be controlled from Tunis; and if Turkey cannot stop slavery in Tripoli, then I should be delighted—though you must take it only as my own expression of opinion, for I do not know whether it is a wise or politic thing to say—I should be delighted to see it in the possession of some great power which, like England or Italy, is whole-hearted in the matter of slavery. I have now told you, at some length, and in a cursory and sketchy manner what is going on, but what I want chiefly to impress upon you is that where slavery exists, there legitimate commerce cannot flourish. A slave will never work as well as a free man. Again, when gangs of slaves are chained together, doing a certain piece of work, when one man stops the whole gang of perhaps thirty will stop; when one man is lame, all walk the pace of that lame man. Slaves do not do one-half or one-quarter of the work that a free man will do, and so long as such an immoral thing as slavery is allowed to continue, so long will you experience the difficulty of getting people to engage in other means of making a livelihood. It is sometimes said, "Ah! but domestic slavery must be allowed." But really, though difficult, the crucial test of our work is—how are we to do away with domestic slavery? I admit that to uproot all the curious family relations which are involved in the continuance of domestic slavery in certain forms would be impossible for a time; but we may at least sow the good seed, even though the full fruition may not be seen in our lifetime. As we have done in India and elsewhere, we should say—the legal status of slavery shall be abolished. It may be impracticable at first to abolish it altogether: it may be unwise to attempt to root it out in households; but we may at all events do this:—If anyone comes and says, "I am so-and-so's slave," let him at once get a free paper. It may not be wise to go into a man's house and ask all about his family relations, but by abolishing the legal status of slavery you will be doing very much—though we must always remember that so long as domestic slavery exists so long will there be a market for slaves. If domestic slavery is legal, a man who is richer than another will buy more slaves. Just as in England a man is pleased to hire more servants, more footmen and coachmen, than his neighbours, so in Africa if a man is allowed to have domestic slaves he will find some means or another of buying them. Let us have nothing to do with the accursed thing Whilst domestic slavery exists, the slave trade will exist, and while the slave trade exists it is impossible for legitimate commerce—the export of English goods and the import of the products of Africa—to exist. Only do away with slavery and you will find commerce will grow and thrive.

DISCUSSION.

Mr. C. D. Collett asked Commander Cameron if he could explain how it was possible for Englishmen to do anything towards the abolition of slavery in Africa, seeing that the British Government had made over the country to the Germans, for the express purpose of introducing forced labour? Looking at the excellent map before him, he expected to hear the agreement which the British Government has made, by which the Sultan of Zanzibar gives over one part of his country to the Germans and another part to the English, either attacked or defended. It is well known that when the Germans took possession of the Custom-house—in fact of the whole country which is marked "under the sphere of German influence," they issued an order that every man in the country should prove his title to his land within six months, or failing that, it should become public land. At the same time the Sultan's flag-staff was cut down, and the people understood clearly that the country had been given over to foreigners. What is the consequence? Our own people, who have been acting in the most admirable way—never interfering politically and yet educating and converting a number of the natives of the East Coast—were advised by the British Government to run away. This indeed they nobly refused to do; but it is only owing to their remarkable propriety of conduct that the whole British influence in that country has not been lost. We are not in this way abolishing slavery, but doing the very reverse of it. We were introducing forced labour, or at least trying to do so. This is a repetition of what occurred on the conquest of the Nile basin, when Sir Samuel Baker declared that his object was to introduce forced labour among the negroes in order that they might buy Manchester goods. The Germans say, "We will put forced labour upon them, and they shall be allowed to buy only German goods." He asked how it was possible to do anything, unless this interference of the Government with the Sultan of Zanzibar were stopped. There seems to be a determination on the part of a large number of people in this country never to treat Mohammedan power with honesty or good faith; and to consider themselves as not bound by treaties.

Captain JOSEPH WIGGINS remarked, that what Englishmen required to know, and what he would like to ask Commander Cameron, was what is the best and most effectual way of dealing with this question.

Commander CAMERON said with regard to Mr. Collett's question that he had rather abstained from speaking about the Germans for diplomatic reasons. He was in communication with the Foreign Office, and was trying to get something put on foot which might have an influence in the direction indicated, but he might say that he knew certain things, with regard to which his mouth was sealed, which would perhaps throw a different light upon the action of our Ministers upon this question. By her Majesty's command, he had an interview with Lord Salisbury and Lord Knutsford, and they greatly deplored the firing at natives, but he was not prepared to state their diplomatic reasons for the course taken. Captain Wiggins asks whether he (Commander Cameron) could give him an idea of what should be done. Well, he was engaged almost night and day in trying to work out an idea, and he had been getting up different meetings upon this question of slavery, and he had told the Archbishop of Canterbury it was a matter of pain and surprise to him that he had not found sufficient members of the Church of England to co-operate in removing the disgrace of slavery. That day week a meeting would be held at Exeter-hall, at which the Archbishop of Canterbury would be supported by bishops, deans, and many members of the Church of England, and by members of all the different religious and missionary societies. At that meeting he hoped to describe in more detail than was then possible a good way of stopping the slave trade. The Bishop of Winchester is a man of acute observation, and it was written to me by Prebendary Barnes, Gordon's old friend, that his great idea was that there should be a highway from Cairo to the Cape. Now this is the central idea. People are working up from the Cape to Zambesi. We kept our word about the fighting at Suakim the other day. We did not go to Handoub, and Handoub has been abandoned, but the day is rapidly coming when we shall have the Nile open again. Now, the idea for which he was working, and for which he had good support, was, that the great line of lakes which we come to by the Zambesi shall be an open highway. Lord Salisbury declares the Zambesi shall be open. The African Lakes Company were going on in their own way at present. He hoped to have their alliance. He had written to Mr. Stephenson, and he seems to approve what he (Commander Cameron) was suggesting. Then we should go by the Tanganyika, and then by the Murita Nzige, up to Emin Pascha's station. We shall establish by these lakes and between them a great central road, and for that we should get authority, English if possible, but if not, international, so that they might have power to maintain order on that line, and by that line one would cut off all these slave-hunting districts from the slave-consuming districts in the East. As for what goes on in the Congo that must be left. There was to have been a controlling International Commission for the Congo, and it was said we might then hope for something. All flags were to be free, but only one flag was allowed there. Still they must make up their minds to have that Congo State under that Commission again. He had got promises of support, pecuniary and otherwise, towards starting this great line, and if that were done they could cut the slave trade into two halves. They would be able to buy the ivory on that highway. He had heard it said that that was contrary to his evidence given twelve years ago before the Slavery Commission. He had said that one hurdle was useless, because the sheep would go on either side of it. But he wanted to put a whole line of hurdles, and then they could not get past. He had, too, the authority of the men whose opinion he cared most for—Sir Richard Burton and others—that this could be done practically without fighting. Some of the better class of Arab traders, who are engaged in slavery, have professed their readiness—and he believed they might be trusted to give up slavery if they can get honourable employment on the other side. He was working for the opening of the Nile, and the making of that line from the Cape working up through Bechuanaland; and when the Bechuanaland Railway, or some such highway, is opened, we shall have what the Bishop of Winchester—and not he alone, but many others—predicts, a highway from the north to the south of Africa. Then you will go straight through the line of the slave trade; you will prevent slaves crossing it by these communications, and you will open trade, civilisation, missionary work. "Evil communications corrupt good manners;" good communications do away with evil deeds.

Mr. MARTIN WOOD observed that with regard to Commander Cameron's proposition, with which all would sympathise—that you must put down slavery in order that commerce may flourish—he would suggest the proposition might be put in another way. If legitimate commerce is extended, it will put slavery down. The two propositions are different; because when you start with the idea that you must put slavery down, you necessarily interrupt the remedial processes for a while, and, in extreme cases, you get into the extraordinary position which our allies, the Germans, occupy in East Africa. Now he would apply that to the circumstances of the Eastern Soudan. Commander Cameron described very clearly how there have been, within the last ten or a dozen years, far more slaves exported thence than before. There was a healthy, steady commerce previously, but that was interrupted, and then slavery set in. Now suppose persistent and earnest efforts were made to restore the legitimate trade to Suakim and that coast, would not that of itself stop the slave trade from going on? There is evidence that the tribes

desire to promote honest commerce. Would not that method be less likely to meet with the reverses which might attend a direct attack upon slavery, and an attempt to remove it at once? He thought, however, that the project of Commander Cameron was a grand one in its conception and objects.

Sir JAMES MARSHALL said, that having resided for ten years in the Government service, in what is known as the Slave Coast, he wished to thank Commander Cameron for reminding them this evening that even if the export trade of slaves is put an end to, that will not put an end to the slave trade which goes on throughout almost the whole continent of Africa, and that the task before them was to put down slavery, not here and there, but over that enormous continent shown in the map on the wall. He would suggest, therefore, that however good this project of Commander Cameron's may seem—and it sounds like a noble one—it must be remembered that slavery is in the very blood of the African, for it may be truly said that every man and woman is either a slave or a slaveholder. He thought, too, it should be more generally known that slavery exists not only on the East Coast but that those parts that are marked on the map with the English colour were full of slaves and slavery. When he went out in 1872 as a judge to the Gold Coast, it was his duty to regulate slavery in the British protectorate of the Gold Coast, and, if necessary, to send policemen to catch runaway domestic slaves. Commander Cameron very properly said that domestic slavery cannot all at once be put down, and that to attempt such a thing would lead only to confusion. It is done away with now on the Gold Coast, but these martial negroid tribes all hunt slaves. The Mussulman propaganda is hunting down all the pagan tribes, and unless they become Mohammedan, they are carried off and sold as slaves. The River Niger on the map is marked as English. Last year he was on Government service up as far as the junction of the River Binue with the Niger, and there he saw Moslem tribes catching slaves; indeed, he had to stop them from sacrificing the slaves. All this was going on in parts of the country that are said to be under the protection of the British Government.

Mr. HYDE CLARKE remarked that Commander Cameron had suggested to some of them very many reflections. When this African Section was first formed—now called the Colonial Section—great expectations were indulged in, owing to the discoveries of Livingstone, Cameron, and Stanley, and it was for the purpose of developing, not only for the benefit of the British Empire but for the benefit of Africa itself, the territories which they had discovered in the line of the Congo, and their predecessors on the lines of the lakes, that this section was instituted. At a later period, when Commander Cameron gave them his views with regard to the expectations which they might justly found, the condition of Africa was entirely different from what it is on that map which he has exhibited. There was a period when there was no Belgian free state, no nominal international free state; there was a period when there was no German trade. At that time the Germans were carrying on trade under the protection of the English flag. At that time there was one general movement, under the protection of the English flag, for the advancement of Africa and for the extension of civilisation. He could not concur in what his gallant friend, Commander Cameron, had said that we were responsible for what ministers might do. How was it that in a moment almost—in mere lightness of heart, these territories were given away — that they were taken from our influence and given over to individuals or to States who acknowledge no responsibility for the advancement of civilisation in Africa. It was in that hall, and in that hall alone almost, that any protest was made against the abandonment of what might be called the rights of their fellow countrymen. Unfortunately it had been left not to these discoverers, who have laid open these regions to culture and civilisation, but to irresponsible persons to deal with these territories and with these populations in the manner which the public journals have described. Commander Cameron had, however, well said, we must take the situation as it is—that the false steps which have been taken cannot be retraced. It is too late now to go against the Germans—they are our kinsmen and now our co-partners. We should, however, as far as possible return to the consecrated policy of England—the abolition of slavery in Africa, and the advancement of civilisation, of commerce, and of culture. With regard to the project which Commander Cameron had laid before them that evening, there can be very little doubt that it is practicable. It is no idle speculation, but, as he had told them, a plan which has been formed by men who know the country, and who know what its possibilities and capacities are. It is really a most lamentable thing that, when one remembers that the line of lakes was discovered by Burton and his successors, that this heritage of England should be abandoned. Something may, it is to be hoped, be now done to retrieve the errors of the past. He would conclude by paying a warm tribute to the energy, zeal, intelligence, and patriotism of Commander Cameron, and would thank him for bringing before that meeting the condition of Africa and the means of its improvement.

Mr. E. H. WILLETT wished to ask Commander Cameron whether the whole question was not involved in the question of porterage in the Central Lakes, from the east to the west coast, and whether a slight line of railway from Ujiji, or a road from the north of Nyassa to Tanganyika would not, in a great measure, do away with slavery. It had been said that it would be a good thing for the centre of

Africa when the last elephant disappeared, because the Arab traders were compelled, in their own interests, to make these raids on the central tribes to carry ivory from the centre to the coast; and that, if they could find an easy method of porterage for their goods, they would abandon the system of massacring the central tribes, and that seemed to him possible.

Commander CAMERON referred to what Sir James Marshall had said about the Niger, and the existence of slavery there. He (Commander Cameron) did not for a moment minimise the evils on the West Coast, and he would do all he could to remove them, but if he took up one part of Africa he could not take up the other. They must remember that they had done a great deal. He had already said there should be no legal status of slavery. With regard to the point suggested, that legitimate trading would beat slavery, he admitted it was a powerful rival; but they wanted something more. The African Lakes Company had to use force. Trade on the Congo had not done everything, and the growth of trade on the West Coast after the suppression of slavery showed that it was not till slavery was suppressed that the legitimate trade could be expected to take firm root. Legitimate trade, admirable as it was, was not sufficient. With regard to what Mr. Hyde Clarke had said, it must be remembered that this cession of British influence had been going on under several Governments, and it was probably the permanent officials rather than the Ministers who were to blame. The last speaker spoke about railways. In 1873 he had written letters to the Foreign and Colonial Offices advocating roads. To be made a beast of burden was only one degree less tolerable than hanging. But it must be remembered that the terminus on the east coast was closed to them. The road, too, which had been partly made by the Lakes Company was now blocked by the slave trader. Communications were necessary to the proper employment of a police force, and when they were made trade would follow and slavery cease. But they must use all sorts of means. The carpenter building a ship used not only a hammer, but a caulking-iron, chisel, plane, and other tools.

The CHAIRMAN wished to say that, to achieve the extirpation of slavery, it was necessary to stop the demand, first, by bringing influence to bear upon the Government to prevent slavery in British territory; secondly, by seeking to influence foreign Governments to adopt a similar policy; and, thirdly, by the introduction of civilisation, by means of a company or otherwise, into those parts of Africa not under European or other powers. He had seen something of domestic slavery in Africa. Three years ago he built a little summer residence up the Nile. One afternoon he obtained the services of a negro to sweep this house out, and, having given him a gratuity, asked him to come back next day. He did not come. He went where he knew he should find the negro, but he found him unable to speak. He then saw that the man's teeth were knocked out, and the reason was simply that he had done this little service. Then as to forced labour. That is almost as bad as slavery. One night he visited a negro plantation in the southern districts of Peru. There was a row of Chinamen with chains attached to their necks, and their feet were bolted together, so that they could move a certain distance, but could not run away. That is an instance of forced labour not under proper control. Then as to trade, trade must be under proper restriction, or merchants will sell brandy and strong spirits, the evil effects of which he had observed on the races in South America. He would conclude by moving a vote of thanks to Commander Cameron for his able and interesting address.

Commander CAMERON, in acknowledging the vote of thanks which had been passed, observed that each one present could become a missionary against slavery. Each of them might influence public opinion, and against the public opinion of Great Britain, when properly aroused, he did not believe any Power could stand.

[NOTE BY COMMANDER CAMERON.—If we cannot interfere in the territory under German influence we still can work outside that sphere. It was the opinion of Sir Bartle Frere that some civilised ruler, white or black, should rule in the interior of Africa, and that then legitimate trade would follow on the suppression of slavery.]

APPLIED ART SECTION.

Tuesday, February 26, 1889; E. MAUNDE THOMPSON, D.C.L., F.S.A., Principal Librarian to the British Museum, in the chair.

The paper read was—

ENGLISH BOOKBINDING IN THE REIGNS OF HENRY VII. AND HENRY VIII.

By W. H. JAMES WEALE.

Bookbinding had nowhere attained to so high a degree of perfection at the end of the 12th century as in England. The leather and other materials employed, and the binding itself, were excellent; the stamps used for the ornamentation of the covers have never been surpassed for beauty of design and execution. But of course a book may be covered with the best materials, and the work may be solidly executed; the tools employed to stamp the covers may even be beautiful, and yet the binding may be without any claim to be considered artistic. What raises binding to the rank of an art is (first) the planning, and

(secondly) the execution of the ornamentation; much depends even on the number of the bands, their diameter, and arrangement. The shape of the space to be adorned by the binder in early times was even more uniform than now; it varied merely in size. Our English binders systematically adopted the plan of dividing the parallelogram into compartments by plain narrow bands, relieved at intervals by small rosettes; yet their fertility of invention was so great, that of the 39 examples which I have as yet discovered no two are alike; indeed, I doubt whether so great variety of design is to be found in the bookbindings of any other period. For some reason, probably owing to the spread of the fashion of covering books with metal plaques, or with silk or velvet, the art of ornamental leather binding died out in this country in the 13th century.

In Germany and the Netherlands it developed more slowly, but it continued to progress during the 14th and 15th centuries. The invention of printing led to a great increase in the number of books produced, and as a consequence stimulated the development of the art of bookbinding, which retained a distinctive character in both countries. The printers who migrated from Germany and the Netherlands were either themselves binders or were accompanied by binders. In Italy there was no national style of binding; what little there was of ornamental leather binding was a mere imitation of Arabian work. The influence of German, especially of Suabian, binders made itself felt there until well into the first quarter of the 16th century, when Oriental designs again prevailed. Into Spain the Germans introduced their system of ornamentation which, however, was quickly modified by the adoption of Moorish details. In France the art was influenced to a very great extent by both Germans and Netherlanders, but in no country was it so completely denationalised as in England, and this is hardly astonishing. From the reign of Richard III., 1483, there had been a constantly increasing influx of stationers into this country from the Low countries, the Rhenish towns, Normandy and Paris. These stationers, who combined the craft of bookbinding with the trade of bookselling, at first paid merely periodical visits to London, Oxford, Cambridge, York, and other towns of importance, but soon seeing that business prospects were good, they took up their abode here. These men brought with them each his own stamps, and followed the traditions of the gild in which they had learned their craft. There were no such gilds of binders in this country as on the continent, and, consequently, there were no strong art traditions. The minor decorative arts cannot flourish except side by side with the higher arts, whose lead they follow. The continental binder had not only the advantage of having had a proper training, but was in constant communication with other art craftsmen, and this naturally tended to improve his taste, and raise the standard of his work.

Books bound during the reign of Henry VII., and the earlier part of Henry VIIIth's, are decorated according to the German, Netherlandish, or Norman fashion. In the later years of Henry VIII. imitation of French and mixed French and Italian designs became the fashion for the more expensive bindings, but the German and Netherlandish systems of decoration were more generally followed. Many foreign stamps seem to have been bought after the death of their original owner, and brought over to this country; others were probably engraved abroad for English binders or for foreigners producing and binding books for the English market.

Here is an example from a Durham book, showing the English system of planning the decoration of a book-cover (Fig. 1, p. 311). The Netherlandish binders generally impressed the sides with one or more panel stamps, the space between these and the edges of the cover being either adorned with ruled lines or relieved with small ornaments. The French plan was to adorn the field with vertical rows of ornaments, or with powdering enclosed within one, three or more borders. The prevailing German plan of design was a framework of intersecting vertical and horizontal bands adorned with stamps, the field within being divided by ruled diagonal lines into lozenge-shaped compartments; these, and oftentimes the spaces between the framework and the edges of the cover, were impressed with stamps (Fig. 2, p. 311).

To William Caxton belongs the honour of having introduced the art of printing into this country. Unfortunately, almost all the copies of the books issued from his press (1477-91) which have come down to our times have lost their original covers. I have here rubbings from the original cover of a copy of the second edition of the "Festiall," and from that of the small Black Book of the Exchequer. It is interesting to note that the border of dragons in triangular compartments closely resembles a stamp used by a contemporary binder at Bruges; the lozenge-shaped stamp with the

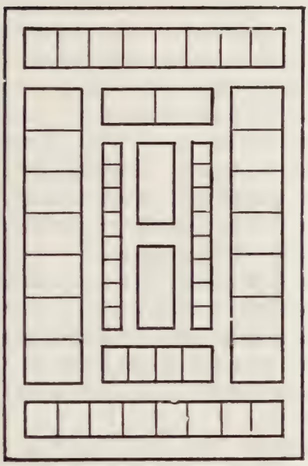
gryphon on the other is quite German in character, as is also the general design.

To John Lettou and William de Machlinia I cannot at present assign any binding with certainty. Wynkyn de Worde, a native of the Duchy of Lorraine, had been in Caxton's employment, and at his death commenced business on his own account, first in Caxton's house at Westminster, whence, at the end of 1499, he removed to Fleet-street. He died at latest in the beginning of January, 1535; his will was proved on the 19th of that month. By it he left to Nowel, the bookbinder in Shoe-lane, xxs. in books; and to Alard, bookbinder, "my servant, vjl. xiijs. iiijd."

Richard Pynson, a native of Normandy, was also for some time in Caxton's employment. In 1493 he was established without Temple Bar; in 1503 he had removed to the sign of "St. George," beside St. Dunstan's Church in Fleet-street. He died, or at least retired from business, in 1529. A good many specimens of his binding have come down to our time. The stamps he used came no doubt from Rouen.

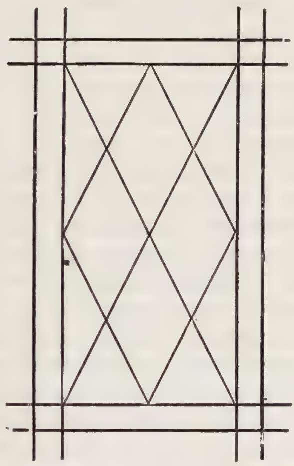
Julian Notary, a Frenchman, was already

FIG. 1.



ARRANGEMENT ADOPTED BY ENGLISH BINDERS.

FIG. 2.



ARRANGEMENT ADOPTED BY GERMAN BINDERS.

established in King-street, Westminster, in 1498. Some time before 16th February, 1503, he removed to the sign of the "3 Kings," without Temple Bar. In 1515 he was settled in St. Paul's-churchyard, by the west door. His trade mark has more the appearance of a notary's than of a merchant's mark, and it is quite possible he may have been a notary as well as a stationer.

Theodore Rood, of Cologne, settled in Oxford in 1478, and went into partnership with Thomas Hunt, a stationer. The stamps used by them appear for the most part to have been brought from Cologne, or perhaps from Brabant; but the general plan of the ornamentation of their binding is decidedly English.

Besides these there were a good many other binders, both English and foreign, exercising their craft in England during the reign of Henry VII., specimens of whose work are still preserved. A deed of foundation of masses by Henry VII., in the abbey church of Hyde,

now in the town library of Bremen, preserves its original stamped binding, with a finely designed panel, of which the Tudor rose is the principal ornament. There are three imitations of this panel, one of which bears the trade mark of the stationer who used it. He was probably a York stationer.

During the reign of Henry VII. several binders made use of two panels to adorn the sides of their book-covers, the one showing a shield bearing quarterly France and England, supported by a dragon and a greyhound, and ensigned with a royal crown; the other, the Tudor rose between two scrolls, supported by angels and bearing the distich :—

> "Haec rosa virtutis de caelo missa sereno,
> Aeternum floreas regia sceptra feret."

These panel-stamps must all date from between the accession of Henry VII., in 1485, and 1528, in which year Henry VIII., discarding the greyhound, placed the dragon on the sinister side, and took the lion for the dexter supporter of his arms. The space around was variously adorned with flowers, tufts of herbage, the sun, moon, and stars, small shields charged with the Cross of St. George, and, if the binder was a citizen, with the arms of the City of London, the last being, as a rule, placed in the upper sinister corner of the panel. The binder's initials are generally beneath the royal arms, and his trade-mark beneath the rose. The earliest example of a pair of panel-stamps bearing these designs is on a volume in the cathedral library at Worcester, unfortunately in very sorry condition; the binder' initials were H.N. The presence of the City arms on a similar pair of panel-stamps used by H. A., proves him to have been a citizen. Another citizen, Henry Jacobi, bookseller, printer, and binder, did not, so far as I know, make use of the second design, but either repeated the first with a stamp representing a gryphon, the same or very like that used in Caxton's workshop, or else a panel representing Our Lady of Pity, with, in the margin, the antiphon: *Salve mater misericordie*, interrupted at the angles by a quatrefoil, and terminated by his initials united by a knot. Another citizen, G. R., did not, so far as I know, make use of the second design; the first he enclosed within a frame bearing a verse from the Psalms; in conjunction with this, he employed a panel-stamp divided into four compartments, each containing the full-length figure of a saint beneath a canopy. Julian Notary used both designs, but not until after he had removed from Westminster, as the city arms occur on both panels. R. L. was not a citizen; he placed a rose and a *fleur-de-lys* in the upper corner of one panel; a *fleur-de-lys* and a shield with the Cross of Saint George in those of another. Another binder, M.D., placed the royal arms ensigned with the crown between two portcullises, the supporters beneath, and the rose and scrolls above. In conjunction with this, he employed a panel stamp with the figure of a saint holding a sword and a shield within a circular medallion surrounded by the Evangelistic animals. I believe him to have been a Frenchman. A citizen, G.G., substituted for the dragon and the greyhound two angels as supporters. Another binder used a panel stamp with the second design, in conjnnction with a representation of the Annunciation, similar to those employed by several Netherlandish binders. Another, R. O., discarded the supporters, and placed the royal arms and the rose in two circular medallions surrounded by foliage on one panel; together with this he used a panel representing Our Lady of Pity, the style of which resembles panel-stamps of Netherlandish bookbinders, who visited or settled in England about this time. It is difficult to decide as to the exact date [of these stamps, but I am inclined to believe that they were all executed before the accession of Henry VIII., after which Queen Katherine's badge, a pomegranate, was added immediately beneath the rose, as on the panels used by E. G. and by John Reynes, of London.

Another ornament used by several binders in the earlier years of the reign of Henry VIII. was a band divided into rectangular compartments containing royal badges. Guy Gimpus placed his trade mark at the foot, and, in four compartments above it, the Tudor rose, pomegranate, *fleur-de-lys*, and turreted gateway with the portcullis, each ensigned with the royal crown. Gerard van Graten, whose trade mark was very similar, adopted the same arrangement. Nicholas Spinerinck placed the gateway in the third, and the *fleur-de-lys* in the fourth compartment. Guy Gimpus made use also of a roll stamp showing a lion, a wivern, and a gryphon facing to left at the foot; Nicholas Spierinck another very similar, but with the gryphon at the foot and the wivern at the top. Another, or perhaps the same binder, adorned his book covers with a broad band divided into four canopied compartments, that at the foot containing three *fleur-de-lys*,

ensigned with the royal crown and his initials, N. S.; the others, the Tudor rose, the turreted gateway with the portcullis let down, and the pomegranate, each ensigned with the royal crown. Other smaller stamps used by these binders seem to have been copied from one another. Another unknown binder, whose initials were L. K. or K. L., appears to have been connected with Julian Notary. He made use of several small stamps representing a rose, a pomegranate, a lion, a portcullis, &c., the letters K. L., and a lover's knot, which, juxtaposed, occur as a border on a volume impressed with Notary's panel stamps. T. H. or H. T. made use of three stamps similar in design, but varying in detail and size. At the foot of each is his trade mark, above which are the *fleur-de-lys*, the portcullis, the turreted gateway with portcullis, the royal arms ensigned with the crown, the pomegranate, and the rose, surrounded by branches of foliage. Very similar stamps bear a trade mark with the initials I. S., or the initials I. H. and H. H. Besides these there are a number of other bindings impressed with stamps representing the badges of Henry and Katherine, but without any trade mark or initials to give a clue to their authorship. One of these binders was probably a German, another of French origin.

Having enumerated all the binders who decorated their book-covers with royal badges during the reign of Henry VII. and that of Henry VIII., down to 1528, I must now make mention of other bindings of that period bearing initials or trade marks.

R. Macé was a Norman bookseller and binder who, I think, visited this country, but did not settle here. His two finest stamps date from the last quarter of the 15th century, but I have not met with any binding impressed with them executed before 1510. P. P. was another Norman—probably Rouen—binder, who bound liturgical books of the use of York.

G. W., whose trade mark occurs on the covers of many books bound in England between 1489 and 1510, was probably associated later on with another stationer, I.G.; an elegantly designed stamp, bearing both marks, adorns many bindings executed between 1510 and 1535.

L. W. was another bookseller and binder, who exercised his craft in the reign of Henry VII. Another binder whose panel-stamps have a thoroughly English appearance, probably lived at the sign of the "Maid's Head," in some provincial city, perhaps Norwich, Lincoln, or York.

Nicholas Spierinck, *alias* Speyrincke, Sperying, belonging to a Netherlandish family of stationers, illuminators, and bookbinders, some of whom were established at Lille, others at Antwerp, came to this country early in the 16th century and settled at Cambridge. He lived in the parish of Saint Mary, of which he was churchwarden in 1516, and was appointed stationer to the University, 20th July, 1534. He was associated with Garrett Godfrey and Segar Nicholson, died in 1545-6, and was buried at Saint Mary's. He brought with him to Cambridge two panel-stamps, with which he had adorned his book-covers prior to settling in this country. Possibly the stamps described may have been employed by this binder, but I have not as yet found them in conjunction with the panel-stamps. Garrett Godfrey succeeded Spierinck as churchwarden of Saint Mary's in 1517, and died in 1539. Andrew Lisley was employed in 1520-21 during 199 days in binding and repairing the books belonging the Eton College library; he was paid fourpence a day in wages, and one shilling a day in commons; the bursar of the college bought for his use all the materials he required. S. G. used a panel-stamp divided into four compartments containing full length figures of saints enclosed within a frame adorned with birds and monsters, alternating with sprays of foliage. I. R., a Netherlandish binder, seems also to have sojourned in England; one at least of his panel-stamps was doubtless designed to adorn the covers of books produced for the English market.

A London binder who used a roll-stamp adorned with an eagle, a bee, a two-headed eagle displayed, a hound, and his trade mark, may perhaps have been connected in some way with John Reynes and with G. W. and I. G.

John Bedel, stationer and bookbinder of the City of London, was the executor of Winkin de Worde's will in 1534. Henry Penwell, another citizen to whom Winkin de Worde bequeathed four pounds in printed books, was a printer as well as a bookseller, binder, and stationer. He carried on his business at the sign of the "Trinity," in St. Paul's-churchyard, from 1518 to 1539; his will is dated the 11th of September in the latter year. He was a zealous Catholic, and in constant business relations with Michael Hillenius of Antwerp, and Claude Chevallon of Paris. John Reynes, printer, binder, and stationer, dwelt at the sign of "Saint George," in St. Paul's-churchyard

from 1527 to 1544. A portrait of this stationer, and a window to his memory adorned the hall of the company prior to the Great Fire. As a binder he employed a number of stamps differing considerably in style. In addition to those already noticed, I would draw attention to the large panel-stamp representing the instruments of the Passion, treated heraldically after the manner of a cut employed by Thielman Kerver. A later panel-stamp is of thoroughly Renascence character. John Cawode, his apprentice and assistant, succeeded to his business. Two other panels bear the arms of Henry VIII. impaling those of Anne Boleyn; one of these had the initials H. A. at the foot.

I have now to mention a certain number of foreign stationers to whom letters of denization were granted after the passing of the Act of Parliament (25 Henry VIII., 1534). Several of these had certainly sojourned from time to time in England, but, probably owing to the importation of bound books being prohibited, they established their domicile here. Henry Harmanson, stationer, from Deventer, in the diocese of Utrecht, was granted letters of denization 19th February, 1535. James van Gavere, stationer, from the dominion of the emperor, obtained similar letters, 2nd of March, 1535, but had probably been in this country for some years previous to that date; he continued to use the same panel-stamp with which he had adorned his book-covers in Flanders. "John Holibusche, *alias* Holybusche, of London, stationer, otherwise bokebynder, born in Ruremond, in the dominion of the emperor," took out letters of denization, 24th February, 1535. Those of John Gachet, *alias* Frencheman, of the city of York, bokebynder, from (Rouen in) France, are dated 10th May, 1535; those of Henry Brikman (Birckman), stationer, from Culemburg, the 19th February, 1535; those of Simon Martinssone, of London, stationer, from Haarlem, 26th February, 1535; and Gerard Pilgrome, of Oxford, stationer, native of Antwerp, 6th March, 1535.

Thomas Berthelet, *alias* Bartlet, probably a Frenchman by birth, was a printer, bookseller, and binder, who carried on his business at the sign of "Lucretia Romana," in Fleet-street. He succeeded Richard Pynson, in 1529, as printer and binder to King Henry VIII., and was the first stationer who received this honour by patent. Henry VIII. granted him, on the 15th February, 1530, an annuity of £4 for life. The arms granted to him by Clarencieux King-of-Arms, September 1, 1549, were:—Azure, on a chevron flory, counter flory between three doves argent, as many trefoils vert. He died shortly before the 26th of January, 1556.

An account of books, &c., supplied to Henry VIII. by Berthelet in the years 1541, 1542, and 1543, occupying twelve leaves of paper, small quarto, is preserved in the British Museum. I have not been able to identify any of the volumes mentioned in this account, but there is in the British Museum a copy of the "Image of Governance," printed by Berthelet in 1540, in its original binding as supplied to the king, and also a manuscript bound for Edward VI. The covers of both these volumes are adorned with gold tooling, the design being in a mixed French and Italian style, or to use Berthelet's own words, "gorgiously gilted after the fascion of Venice." Another volume, presented to Henry VIII. by Antonius de Musica in 1544 or 1545, has a French-Italian border, but the general treatment of the design is of a very mixed style and inferior character.

From this time, on until the end of the century, all the best work done in London was executed by foreign binders.

The paper was illustrated by a series of rubbings by Mr. Weale, kindly lent by the Lords of the Committee of Council on Education. Other rubbings were exhibited by Mr. E. Gordon Duff and Mr. H. S. Richardson, and some specimens of bindings were lent by Mr. Zaehnsdorf and Mr. Weale.

DISCUSSION.

The CHAIRMAN said every one must have been much interested in the paper read by a master of the art, Mr. Weale being probably the only gentleman in England who knew the history of bookbinding by experience in the most thorough way. He had been engaged for years on a work which he hoped would soon appear, and there was probably hardly a library in England where he had not gone through a deal of hard work in the way of rubbing. This paper dealt with what might be called the foreign period of English bookbinding; but around the walls were arranged rubbings from about the beginning of the 13th century, from which some idea might be gained of the early history of the art. It was not to be wondered at that an art such as bookbinding should have given way at the end of the 15th century, when they knew that other arts in England did so likewise. Foreigners came to England and were employed in every art. To corroborate what had been said as to the care which should be taken to examine old bindings, he might

mention that a friend of his, who examined them in a like way, though he had not made such a find as Mr. Weale had spoken of, discovered on one occasion a £5 note in a book cover.

Mr. E. Gordon Duff said he had not had the opportunity of working long on this very interesting subject, but he had succeeded in obtaining some new information, and though Mr. Weale had not left much there was still something to be done. To show how necessary it was to examine the boards of old bindings, he might say that in taking to pieces one of Speyrinck's he found the name written on the inside. Speaking of the connection between foreign and English binders in the 15th century, it was interesting to refer to the two first Oxford stationers, Rood and Hunt; Rood came from Cologne, and Hunt was an English stationer. The foreign stamps brought to England by Rood were used in their work in the English manner, and this fact formed one of the important links in the history of English binding.

The Chairman said Mr. Richardson had placed an interesting collection of rubbings on the table, and perhaps he would be able to say something about them.

Mr. H. S. Richardson said he had very little to add to Mr. Weale's exhaustive paper. He had been a rubber of bindings and a student of the art for some long time. It was a very interesting subject, and well worthy of further exploration, but he had been rather discouraged by finding it so difficult to discover the names of the binders. You got the initials on the cover, but he had not been able to discover many clues to the names. Mr. Weale appeared to have been more fortunate, and he should anxiously await the publication of his important book.

Mr. W. A. Tyssen Amherst, M.P., said he thought they had all learned one very good lesson, viz., to do as he impressed upon all his friends, not to discard old bindings. He thought a book looked much better in its old binding, even if shabby, and if it were in oak covers, and the corners were torn, he would rather not see them mended. It took off a good deal of the character of an old book, and there was a great charm, when you could find a book of the 15th century, to feel that you had it in the same state as it was received from the hands of perhaps the first of English binders. They owed a great deal to modern binders, of whom some of the most celebrated were English, such as Mr. Bedford, and others whose loss they greatly regretted, whilst some still remained amongst us, and would no doubt carry their art to great perfection; but at the same time it did not do to mix the new too much with the old. He thought these gentlemen would have plenty of scope for their talents in modern books, and he hoped they would deny themselves the temptation to help in the renovating of old ones. He had read, in common with others, of interesting discoveries being made within the pasted leaves which formed what were now termed mill boards; there was the well-known story of several Caxtons, which were only discovered from the leaves being pasted in the cover of some later book. Therefore those who, like himself, were book collectors, had plenty of field for research, and there was much to stimulate their hopes. If he discovered anything, he should hasten to communicate it to Mr. Weale, for he was sure they were none of them anxious, if they discovered anything, to keep it to themselves, but to share it with those who took an interest in the matter. He begged to thank Mr. Weale for his very interesting paper, and hoped when he had anything further to communicate he would not forget the Society of Arts.

Mr. H. B. Wheatley said Mr. Weale was so thorough a master of his subject that it was difficult for others to follow him. He was a pioneer, for before he dealt with these covers little or nothing was known about their history; and they were indebted to him, especially for the discovery of the fine English leather bindings of the 12th century. It was not only interesting to book lovers, but also to artists, to learn that as early as the 12th century English art was superior to most of the continental art of the time. It was also a great thing that he had been able to give so many names of binders, for it was a great disappointment to those who saw a binding which they very much admired not to be able to tell to whom they owed that pleasure. Mr. Weale had so exhaustively hunted up these details in so many registers, that he had discovered a great many names which were quite unknown before. It was also interesting to see these specimens of binding by the old printers. It had often been said that it was almost impossible to get a cover of Caxton's, because the books were so valuable that earlier collectors had always put them into handsome covers, and to get a genuine cover was quite a find. He hoped Mr. Weale would succeed in finding such other covers of our great early printers as he had not yet obtained. It was interesting to learn the schemes of arrangement of these stamps which were shown in the diagrams and described. Most of these were small stamps, but there were also some figure-pieces, most of which were heraldic or had some connection with the possessors of the books. One might have expected that some books of engravings might have had designs placed upon the covers of the same character, but he did not know that that had been done. Mr. Weale had spoken of the Italian designs and of some of the later English designs, but he did not mention the distinction between the gold and the blind work. This was exceedingly important, because the gold work was a distinct art; it had a different origin and different methods from the blind work, and we confuse the history of the subject when this distinction is not borne in mind. A few words at the

beginning of the paper, as to the manner in which decorative arts flourished by the side of the higher arts, were very important. He thought in regard to binding, some of the professors of the art were too apt to copy the specimens of earlier binding; but he thought the more the binders of the present day could learn from the higher arts of the time, the better and more varied would be the work they produced.

Mr. WEALE, in reply, said Berthelet was the first to introduce gold binding into England, and he knew of no earlier example of gold tooling than his work, and therefore it hardly came within the scope of the paper. He had a large number of rubbings of gold tooling in the collection he had formed for South Kensington, but it would require a paper by itself to deal with that subject. From the time of Berthelet, right on through Queen Elizabeth, Mary, and James, the whole of the best work of that kind in England was done by foreigners. In many cases where in libraries the work was attributed to English binders, it was really done in Paris; in many cases even in the British Museum books thought to be English were really Parisian, being exactly the same as books which had never been out of Paris to this day. For a long time the art of gold tooling could hardly be looked upon as an English art, for though it might have been executed here it was done by foreigners. The finest examples he knew were those done for Robert Dudley, Earl of Leicester, who was very fond of this kind of work, but they were in much better taste than the generality. Those bound for Queen Elizabeth were sometimes very fine, but generally the corner and central pieces were not at all in proportion, a defect which was never found in good French work. The same borders were used for folio and octavo, when, of course, they were out of proportion for one or the other In the English work of that date there was great want of taste; the binders got hold of good tools, but the work was not well done. Some entries in the Registers of the Stationers' Company throw great light on this matter. There were regulations made against the introduction of foreign binding, and we had very strong proof that the good work of that day was really done by foreigners, as late as 1600. He did not think the revival of binding in this country could be put earlier than the time of Charles, when there seemed to have been an English binder at Eton who formed a good many good workmen, some of whom came to London and settled. He might have an opportunity to say something about them on another occasion.

The CHAIRMAN said it was devoutly to be hoped there was no further period of renaissance at hand, when we should have to call in foreigners to do our binding for us; but that the English binders would be able to hold their own not only in workmanship but in taste. Mr. Weale had drawn attention to the wonderful amount of ornamentation on book covers in early times, and the different shapes which the ornaments took in England, France, and Germany, and the Netherlands. It might strike a person only accustomed to a modern library as rather strange that books should be ornamented in this extreme manner; but it must be remembered that in early times books were not placed upright and close packed on shelves, as they were now; this did not begin until after the 15th century. Until then they were always placed on their sides, and thus the ornamented covers sustained no injury. Many years ago, taking an interest in this subject, and seeing in the department over which he then presided that the MSS. in ancient bindings were scattered about, he brought them together by degrees, and in that way he learned a good deal about them. He had not had much time to devote to it, but he was able to form certain rough ideas as to the course of book-binding, and might mention one or two points. In the first place he noticed that early book covers—not the very early ones, which were ornamented with plaques, jewels, and so forth, but the wooden boards covered with skins—were always cut flush to the leaves; they did not project as in modern books, in order to protect the bottom edges when the book was placed on the shelf. Of course, when the book was not placed upright, it was not necessary to have the edges of the covers projecting. That system went on certainly down to the end of the 14th century, and then the covers began to project a little, and in the 15th century they increased. Another reason why books could not be placed on their ends was that the heavy covers were strengthened with bosses, nails, and so forth, which would be unpleasant neighbours for other volumes to come in contact with. There were also one or two peculiarities in different nations. In western Europe you could not tell from the shape of a book cover from what country it came, but in the east, as in Greece and Bulgaria, there was always a peculiar groove down the edge of the cover, the reason for which he did not know. You could always recognise an east of Europe binding by this groove, even though stamps were used which evidently had come from the west. Coming down to the time of which Mr. Weale had been speaking, the bindings of Henry 8th; it was about that time when velvet bindings became fashionable; embroidery was used earlier, but embroidered velvet was first used then. Again, people might wonder when they saw a modern ledger why it had those peculiar bands ornamented with lattice work of narrow parchment strips, but these were a survival, or rather a reminiscence, of the time of Henry VIII. At that time ledgers were literally bound in that way; they had a broad band of leather brought round the back, and stitched through and through with these narrow strips of parchment, which had continued down to the present day. In fact, even in a penny washing-book you sometimes found the same pattern stamped upon the sides. It was an old fashion retained, just like the buttons at the back of a coat, which were merely survivals of what was once a

necessary part of the dress. He concluded by proposing a hearty vote of thanks to Mr. Weale, which was carried unanimously, and the meeting adjourned.

TWELFTH ORDINARY MEETING.

Wednesday, February 27, 1889; EDWARD C. ROBINS, F.S.A., Member of Conncil, in the chair.

The following candidates were proposed for election as members of the Society:—

Bernard, Sir Charles Edward, K.C.S.I., 44, Bramham-gardens, South Kensington, S.W., and India-office, S.W.
Collenette, Adolphus, 11, Commercial-arcade, Guernsey.
Flower, Thomas James Moss, 1, Passage-street, Tower-hill, Bristol.
Horncastle, Henry, Chobham, near Woking, Surrey.
Richards, Edward Harrinson, Lagos, West Africa, and St. George's Club, Hanover-square, W.
Richardson, William, Florence-villa, 121, Pershore-road, Edgbaston, Birmingham.
Stevens, Joseph Wallace, Belph, Whitwell, near Chesterfield.
Thurston, Frederick, Hastings-street, Luton, Beds.

The following candidates were balloted for and duly elected members of the Society:—

Dewick, Rev. Edward Samuel, M.A., 26, Oxford-square, Hyde-park, W.
Gutteridge, Richard Sandon, M.D., 58, Brook-street, Grosvenor-square, W.
Howell, John Charles, 23, De Vere-gardens, Kensington, W.

The paper read was—

THE IRISH LACE INDUSTRY.

By ALAN S. COLE.

Within the last four or five years I have been brought into contact with persons interested in maintaining the Irish industry of lace-making, as well as with those who supervise and follow the industry. And it is in consequence of results which have been produced during that period that I have ventured to offer you some remarks upon them, and the lessons they seem to teach.

The history of lace-making in Ireland, from its commencement in the last century, has been told in the catalogue of the Mansion House Exhibition of Irish Lace, held in 1883. It is scarcely necessary, therefore, to repeat it now. We have to deal, I hope, more with the future than with the past. In 1883, my own connection with the industry commenced. During that year exhibitions were held at Cork and at Limerick, and at each of them sections were devoted to the display of Irish laces. Irish lace-making was then being discussed from somewhat new points of view. A Royal Commission was meeting in Ireland, and taking evidence on technical instruction and its relation to industries. The promotors of the Cork and Limerick Exhibitions, possibly influenced by what had passed at the meetings of the Commission, considered that it would be well if lectures upon lace-making, the history of its rise and development in other countries, with a review of the many kinds of ornamental patterns used from the 16th century to modern times, could be delivered in connection with the laces shown at their exhibitions; and I was deputed by the Department of Science and Art to deliver two such lectures at Cork and at Limerick. It appeared to me that if these lectures were to be of any practical value, typical specimens of Irish laces should be compared side by side with Italian, Flemish, and French laces, which seemed to be the prototypes of, or sources of inspiration for Irish laces. Comparisons, as Dogberry says, are odorous, and certainly those I ventured to make, together with the remarks they entitled me to offer, were found so in certain quarters. They were much criticised in the newspapers; and a gentle controversy fanned into a new and more definite phase the somewhat flickering interest shown in Irish lace-making. Some there were who stoutly maintained that the ornament and patterns of Irish lace were of such a national character that it was wrong to asperse them on that score. Others took a different view, and came to the conclusion that Irish lace could be vastly improved in all respects, if some systematic action could be taken to induce the lace-makers to work from more intelligently composed patterns than those in general use. There was a consensus of opinion that the workmanship of Irish laces was good, and that it could be applied to better materials than those ordinarily used, and that its methods were suited to render a greater variety of patterns than those usually attempted. The industry was suffering from great depression, however, sales were most uncertain, and prices so low as to cause dismay to the unfortunate workers engaged in making the lace.

These and other circumstances seem to have prompted the promoters of the Cork Exhibition

to further efforts in the cause of lace-making. Towards the close of the year 1883 they made fresh representations to Government, and inquired what, if any, forms of State assistance could be rendered. A number of convents in the neighbourhood of Cork were engaged in giving instruction to children under their care in lace and crochet making. At some, rooms were alloted for the use of adult workers, who made laces under the supervision of the nuns. These convents obviously were centres at which experiments in reform might be tried. The convents, however, lacked instruction in the designing of patterns for lace. An excellent school of art was at work in Cork, but the students there had not been instructed in specially designing for lace. If the convents, with their work-rooms, could be brought into relations with this school of art, it seemed possible that something of a serious character might be done to benefit lace-makers, and also to open up a new field in ornamental design for the students at the school of art. The rules of the Department of Science and Art were found to be adapted to aid in meeting such wants as those sketched out by the promoters at Cork. As the nuns in the different lace-making convents had not been able to attend in Cork to hear my lectures, they asked that I should visit them and repeat them at the convents. This I did early in 1884, the masters of the local schools of art accompanying me on my visits. Negotiations were forthwith opened for connecting the convents with the art schools. By the end of 1885 some six or seven different lace-making convents had placed themselves in connection with schools of art at Cork and Waterford. These convents were attended not only by nuns, but also by outside pupils; and at the request of the convents I have visited them twice a year, lecturing and giving advice upon designs for lace. The students of the convent classes sat for the annual Government examinations in drawing and various branches of ornamental design, upon the results of which the convents were able to claim payments. The composition of new patterns for lace was attempted, and old patterns, which had degenerated, were revised and re-drawn for the use of the workers connected with the convents.

All these operations have since developed the promise of becoming thoroughly recognised as a necessary part of the convents' regular business in providing for the cultivation of such a home industry as lace-making. There are now twelve convents where instruction in drawing and in the composition of patterns is given, and some of the students have won some of the higher prizes offered by the Department of Science and Art for designing lace patterns.

Aided by funds granted from the profits of the Cork Exhibition, and by a grant from Government, the Cork School of Art, three years ago, acquired a collection of finely-patterned old laces. Whilst the main portion of this collection is publicly displayed in the galleries of the Cork School of Art for consultation by designers and workers, selections from it are freely circulated through the different convents connected with that school. They have also the privilege of borrowing similar specimens of old lace from the South Kensington Museum. So successful has been the system of education pursued by Mr. Brenan, the headmaster of the Cork School of Art, that two female students of his school, last year, gained the gold and the silver medals for their designs for laces and crochets, at the national competition which annually takes place in London between all the schools of art in the United Kingdom. In addition to this I ought to say that the designers at the Cork School of Art are receiving orders from dealers and others to make new patterns for laces.

Now, whilst the organisation above-mentioned was in progress, many lace-makers, not connected with Cork, Waterford, or the branch classes at the convents, were not being affected by it. Accordingly, to meet this deficiency, but, of course, in a very limited degree only, a committee of ladies and gentlemen interested in Irish lace-making raised subscriptions, and determined to spend a large share of them in prizes to be competed for by designers generally. A certain number of the designsr although well composed, were not easily workable by lace-makers. Consequently, those which were practicable had to be picked out, and of these even some had to be modified. But the result, in the end, was that a fair number of the prize-winning designs were placed out with lace-makers and accordingly worked. The funds raised amounted to some £370, and of these £190 has been distributed in prizes and payments to designers. About £160 has been paid by the committee to lace-makers for trying experiments with, and producing finished samples from, many of the prize and other designs.

The collection of specimens exhibited this evening includes almost all such finished samples. Besides these, other more important

pieces have been made for her Majesty the Queen, the Marchioness of Londonderry, the Countess of Aberdeen, Lady Dorothy Nevill, Mrs. Alfred Morrison, and others. Mrs. Alfred Morrison has been a most generous patron in this direction, giving orders for lace in the spirit which actuated those liberal amateurs of the arts, to whom the world is indebted for encouraging its artists to produce their best work.

It has been said that £1,000,000 worth of foreign lace is imported into this country yearly. Of this, however, more than three-fourths is for machine-made lace—a very different fabric from hand-made lace. Of the remaining fourth it is difficult to estimate how much may be credited to hand-made laces, and how much to embroideries, as these two classes of work are not, I believe, separated in the returns of imports. In any case we may, perhaps, take it that £200,000, at most, are annually spent by the ladies of this country in foreign hand-made laces. But I imagine that hardly £20,000 a year is spent by this country upon Irish laces; a very small sum as compared with the many hundreds of thousands of pounds spent every year by the kingdom upon laces, trimmings, and such like. Almost the whole of this small sum—whatever it may be—expended on Irish laces, goes in what may, without detriment, be called "cheap laces." And yet, as I hope to prove to you, it is possible to produce Irish laces of artistic quality, which is of as high a standard as that of some foreign hand-made laces. The finer qualities of hand-made laces can only be produced through the exercise of very considerable taste in conjunction with careful, dainty labour. They are works of art. Although they are not articles of ordinary commerce such as give employment to the larger number of workers, they react upon the character of the less artistically important laces, and can stimulate the vitality of the hand-made lace trade in all its branches. But one obstacle to enterprise in making artistic laces of value is the fickleness of fashion to which ladies succumb. One hears repeated professions of admiration for fine hand-made laces, but the acting up to such professions is the exception, and not the rule. The admiration amounts to little more than an expression of momentary pleasure at seeing hand-made lace.

A few years ago, Mr. Ruskin uttered some opinions upon machine-made and hand-made lace which seemed to bear so closely upon the subject before us, that I venture to quote them.

"There is still some distinction," he said, "between machine-made and hand-made lace. I will suppose that distinction so far done away with, that a pattern once invented, you can spin lace as fast as you now do thread. Every body might then wear not only lace collars but lace gowns. Do you think they would be more comfortable in them than they are now in plain stuff—or that when every body could wear them, anybody would be proud of wearing them?......You don't think that it would be convenient, or even creditable for women to wash the doorsteps or dish the dinners in lace gowns? Nay, even for the most lady-like occupations—reading, or writing, or playing with the children—do you think a lace gown....so great an advantage or dignity to a woman, If you think of it, you will find the whole value of lace as a possession depends on the fact of its having a beauty which has been the reward of industry and attention.

"That the thing itself is a prize—a thing which everybody cannot have. That it proves by the look of it the ability of its maker; that it proves by the rarity of it, the dignity of its wearer—either that she has been so industrious as to save money which can buy say a piece of jewellery, of gold tissue or of fine lace—or else that she is a noble person to whom her neighbours concede as an honour, the privilege of wearing finer dress than they.

"If they all choose to have lace, too—if it ceases to be a prize—it becomes, does it not, only a cobweb.

"The real good of a piece of lace, then, you will find, is that it should show, first, that the designer of it had a pretty fancy; next, that the maker of it had fine fingers; lastly, that the wearer of it has worthiness or dignity enough to obtain what is difficult to obtain, and common sense enough not to wear it on all occasions."

Now, as regards Irish lace generally, one of the causes of its threatened extinction as an industry was that, through a demand—in character like that for machine-made lace—the workers were pressed and hurried to produce their work. Quality was thereby sacrificed for quantity, for many peasants, with anything but "fine fingers" or "pretty fancies," applied themselves to making yards upon yards of material which dealers passed into the market as Irish lace. And so it followed that the more discerning of the public became tired of this outpour of the same clumsy webs and tissues placed before them as Irish

lace. Other sections of the public preferred machine-made laces. The dealers apparently did not find it worth their while to do much towards remedying the situation. For the most part they were buyers and sellers. If Irish lace didn't answer their purpose, machine lace and other vendible articles, like groceries or boots, did. Thus Irish lace earned a bad name, the wearing of it fell into desuetude, and the reaction therefrom bore heavily upon many who did not deserve it. The improvement of feeling towards Irish laces must, I think, be looked for in cultivating such conditions as Mr. Ruskin has traced. This opinion is shared by one, at least, of great experience in the lace trade with whom I have had the advantage of frequent conversations; I allude to Mr. Biddle, the chief partner in the business of Messrs. Haywards. In a recent letter he writes:—"I made up my mind that if anything could be done to have any lasting effect upon the lace industry it must be done by the introduction of novelties." Here, then, we have, in other words, very much what Mr. Ruskin described as "pretty fancy." "Irish people," continues Mr. Biddle, "don't like trouble, and are not good at detail like the French, but it is no use at all to give way, and allow them to continue at the same patterns and shapes."

I may interpose here that, although I have found that very many Irish people don't like trouble, I have met with some who take a great deal of trouble to do their best, and am glad to say that Mr. Biddle has testified to his experience of this by the commissions he has given not only to students in the Cork School of Art for new lace patterns, but also to some of the lace-makers at the convents for carefully-wrought lace. Beyond this, he has caused a handsome sort of silk-crochet—called "Royal silk guipure"—to be made lately. For one of the first bits due to this new and successful departure in Irish lace-making, Mr. Biddle employed one of the principal prize winners, an Irishman, who would probably not have been discovered for such work if it had not been for the committee, to which I have referred, having offered prizes. Mr. Biddle concludes his notes to me by writing:—"I am of opinion that if we are content to reproduce the beautiful patterns of the lace of past centuries, and adapt them to modern shapes and fashions, we may continue to sell these productions on their own merits."

Dealers in lace at Dublin, like Mr. Ben Lindsey and Messrs. Forrest, as far as I have been able to judge, are beginning to move along the same lines. Formerly, Dublin dealers would buy patterns from designers at Brussels or Paris; now, however, they send occasionally to the Cork School of Art for designs. This, then, should be somewhat encouraging to the Irish lace-makers, and to the designers of patterns, who, as is the case with those at the Cork School of Art and its branches at the convents, base their work upon the study of fine examples of old laces.

The notion has been promulgated, and is still partly adhered to, that the lace-maker is the person to make the design. This may be an ideal condition to try for. But from the 16th century forward the patterns for ornamental laces have always been designed by ornamentists having knowledge of the composition of ornament, and of the materials for which they were called upon to design. Lace pattern books were published in considerable quantities in Italy, France, and Germany during the 16th and 17th century, and from these the lace-makers worked. In the 17th and 18th centuries, when lace patterns became much more elaborate, amongst the French designers of them there were such ornamentists as Berain and Le Brun. In a measure the designers are to the lace-makers what authors are to printers. Few publishers, I fancy, would try and drive a trade in the sale of literature by relying upon what their printers chose to write. And on the other hand, few authors would care to turn their untrained hands to setting the type and pulling from it splendid editions of their own writings. If my simile be fairly correct, it will be clear that it is more or less of a mistake to expect lace-makers to compose and draw their own patterns. For these the exercise of a pretty fancy and of a talent different from that of skilful needlework is necessary. Many lace-makers would no doubt derive benefit from practice in drawing, and in discriminating well, from badly, shaped forms. But the skill they are primarily required to show and to develop is one of fine fingers in reproducing beautiful forms in threads. The conception, arrangement, and drawing of beautiful forms for a design have to be undertaken by ornamentists acquainted with the limitations of those materials and methods which the ultimate expression of the design involves.

Abroad, the lace dealer—or manufacturer, as he is called, employs on his staff one or two designers, who are kept as busily at work as the clerk in his counting-house or the seller

in his shop. The foreign lace manufacturer also buys designs from unattached and independent designers, who understand the various makes of lace. At home a similar condition is not to be found in respect of hand-made lace, although it exists for machine-made lace. At present the convents and schools of art in the south and west of Ireland have seriously commenced to study the question of supplying the workers with new patterns, and experimenting with new effects. But this element in reforming Irish lace is very young; its support and development are very largely in the hands of the dealers.

There are seven different sorts of Irish lacework, each implying a peculiar method of make. They may be briefly named as follows:—

1. Flat needlepoint lace.

2. Raised needlepoint lace.

3. Embroidery on net, either of darning or chain-stitch.

4. Cut cambric or linen work for patterns in the style of *guipure* and *appliqué* laces.

5. Drawn threadwork in the style of reticella and Italian cut points.

6. Crochet laces.

7. Pillow and *torchon* laces.

The products of these different classes of work may be used for articles of costume, trimmings, flounces, handkerchiefs, &c., and for furniture purposes, cushion-covers, doyleys, quilts, &c. And diagrams of these will be thrown on to the screen. But first of all I would ask you to let me say a few words about the different makes of laces.

Flat needlepoint laces are made at Kenmare and Youghal, under the direction of the convents there. Raised needlepoint laces are made at Innishmacsaint, near Lough Erne, under the direction of Miss MacLean, who has long taken the deepest interest in this work. Similar laces are also made at New Ross, County Wexford, under the direction of the Carmelite Convent there. In other parts of Ireland, also, there are workers producing needlepoint laces. Unfortunately, these latter are left almost entirely to their own resources in respect of pattern and the use of fine material.

Embroidery on net—in chain-stitch ("tambour work") or darning ("run") work, is commonly known as Limerick lace. But there are workers of it in many places besides Limerick. The larger quantity of the stuff sent into the market within the last ten years, under this name, has been of gross material, scamped and irregular workmanship from ill-drawn patterns. Mrs. Robert Vere O'Brien, of Old Church, Limerick, however, has proved what admirable artistic results can be secured by engaging labour upon good patterns and materials. Her efforts have been most successful. At the commencement, three years ago, the sales of the workers brought in some £30 or £40; last year they were nearly £400, and these facts have served to promote an influentially supported movement in Limerick. Under the guidance of Mrs. Vere O'Brien, Mr. A. W. Shaw, and others, a small training school for lace-makers is being started, and is to co-operate with the Limerick School of Art as respects new patterns, and with the principal lace dealers of the town as respects commerce. Beyond this, the dealers at Limerick, Messrs. Channock and Messrs. Todd, find an improved and ready sale for their Irish laces. At Kinsale the Convent of Mercy has a capital class of Limerick lace workers, besides a good art class, some of the students in which have produced very promising designs. The Presentation Convent, at Tralee, has built new rooms for use as an art school and as a lace school, and will no doubt soon get into working order.

Carrickmacross lace is another sort of embroidery either upon net or with fine linen and cambric. But in this, too, the dire influence of deterioration in pattern and materials are too common. Nearly forty years ago a drawing school was established at Carrickmacross; none exists now, at least none in connection with the leading lace school there—the Bath and Shirley school. Thirty-eight years ago the children making lace were instructed in drawing, and were taught to "take a sprig here and a sprig there, and to incorporate them" into a pattern. The mistress of the lace school would sometimes "take two or three patterns and throw them into one." I am quoting from evidence given before the Royal Commission on technical instruction. It is interesting as showing an idea of a happy-go-lucky and perfunctory method of designing ornament.

Drawn thread-work and geometric-patterned needlepoint laces, or reticella, are made in small quantities by workers under the supervision of Miss Keane, of Cappoquin, and Mrs. Hall Dare, of Newtownbarry.

Crochet-making in Ireland is certainly a wide-spread industry; it has suffered much from the want of supervision and direction. A good many hundreds of women making crochet

are scattered throughout Ireland. The principal centres appear to be those in Cork, in Wexford, and the district about Clones, Counties Monaghan, Cavan, and Fermanagh. Something has been done towards introducing improvements in crochet, as we shall, I think, see. But much more could be done were the provision of patterns, the distribution of standard specimens, made by the best hands for imitation by the less skilled, and the supervision and collection of the work to be more intelligently cared for than they now are as a rule.

A firm of lace and crochet dealers in Cork had almost given up hopes of being able to find a sale for crochet three years ago. Their workers at one period numbered scarcely 100, and their employment was irregular; now, however, the workers cannot turn out work rapidly enough to supply the demand which has arisen within the last two years. I am told that the firm in question (Messrs. Dwyer) are employing 500 workers, and these workers have continuously employed for the last six months. If this condition is not immediately attributable to the action of the convents, the schools of art, and the private committee, at least it is coincident with it. Improvements have been made in many of the patterns lately issued by this firm, and the demand for the new sorts of crochet laces is good.

The nearest approach to artistic pillow lace-making in Ireland is that which exactly follows the lines of Devonshire, or Honiton, lace-making, an industry which I fear is dying out. Some few centres are springing up in the wilder districts of Mayo, Galway, and Donegal for the manufacture on the pillow of *torchon* or small trimming laces. These are the simplest pillow laces which are made; the patterns for them are of quite an elementary character. Mrs. Power Lalor, the inspector of lace-making in Ireland, has paid a good deal of attention to this class of work, and reports that the workers at the Galway centre are fully employed. At the same time, it may be well to note that this sort of lace, for which there is undoubtedly a large demand, is made in immense quantities at the villages and towns in the Auvergne, the historic district for such *torchon* lace. The Irish *torchon* centres have therefore to face a direct and severe competition. The Auvergne *torchon* makers, however, with all the advantages of inheriting close on 300 years' traditional practice in the work, and of being under organised supervision of dealers' agents, can make but a scanty livelihood. This industry is unquestionably suited to such districts as those in Galway and Mayo, where there are many almost destitute women; and although the rate of wages may not at times exceed 1s. 6d. a week, such an earning is a vast improvement upon nothing at all, and the disciplinary training to do such work is a valuable substitute for an apparently unavoidable absence of employment.

The sales, at the various convents which have been referred to, have year by year improved; and all these convents tell me that they consider the improvement largely due to the steps they have taken to attend more carefully to the composition of the patterns, and the way in which they should be wrought into lace.

I think it will be seen that an exercise of new talents in composing patterns for lace, and of skill on the part of the lace-makers in reproducing such patterns in the fabric for which they are designed, has been educed. Impetus has been given to local enterprise. It has been supplemented by State aid; and with a continuance of this aid, it seems to promise a continuity of action in securing results that are possibly more lasting in their effect than those which follow from spasmodic or merely personal philanthropy, good as this may sometimes be. It rests with others than myself to make any general statement upon how far trade has been affected. The publicity given to the efforts which have been made has no doubt contributed towards reviving a taste for Irish laces; and dealers have therefore perhaps been encouraged to give closer attention to the use of new designs and better materials.

I will now bring before you diagrams of a few specimens of Irish lace made from old and new patterns:—

1. This is the corner of a handkerchief of Limerick lace—tambour work. This is a common pattern of shamrocks surrounding a harp. The details, leaves, and harp are clumsily drawn, and the general distribution not good.

2. The next slide gives us three borders to match. The pattern was designed by Miss Anderson, of Cork, who adopted a Point d'Alençon pattern of the 18th century. There is more variety of floral details in this than in the previous specimen, and greater opportunities for using various ornamental fillings between the twisting sprays. The scheme of this design is better thought out. These

borders are of tambour work, and were made at the St. Vincent's Convent, Cork.

3. The next is a deep flounce made at Mrs. Vere O'Brien's school at Limerick, from a design with wreaths and garlands of flowers. The design was made by one of the nuns at the Convent of Poor Clares, Kenmare.

4. The next slide is of Limerick tambour lace, made at the Convent of Mercy, Kinsale. The design is one of Miss Anderson's earlier attempts.

5. It was thought that it might be well to see how Limerick lace would do for curtains. A design was made by Mr. Michael Hayes, of Limerick, and here is the result of the experiment.

A second class of Limerick lace is that known as "run" work, or where the em-

FIG. 3.

INSERTION OF CARRICKMACROSS APPLIQUE LACE DESIGNED BY MISS ANDERSON.

FIG. 4.

BORDER OF LIMERICK LACE DESIGNED BY MISS ANDERSON.

FIG. 5.

FIG. 6.

BORDERS OF LIMERICK LACE MADE FROM DESIGNS BY MISS ANDERSON, UNDER THE DIRECTION OF THE ST. VINCENT CONVENT, CORK.

broidery is done by darning instead of by chain-stitching (tambour).

6. The specimen before us is a corner of a handkerchief from an old pattern. In this the shapes of the leaves and flowers are lumpy.

7. Of the same class of work, but I think more dainty in effect, is this scarf, designed by Mrs. Vere O'Brien, and worked at her school.

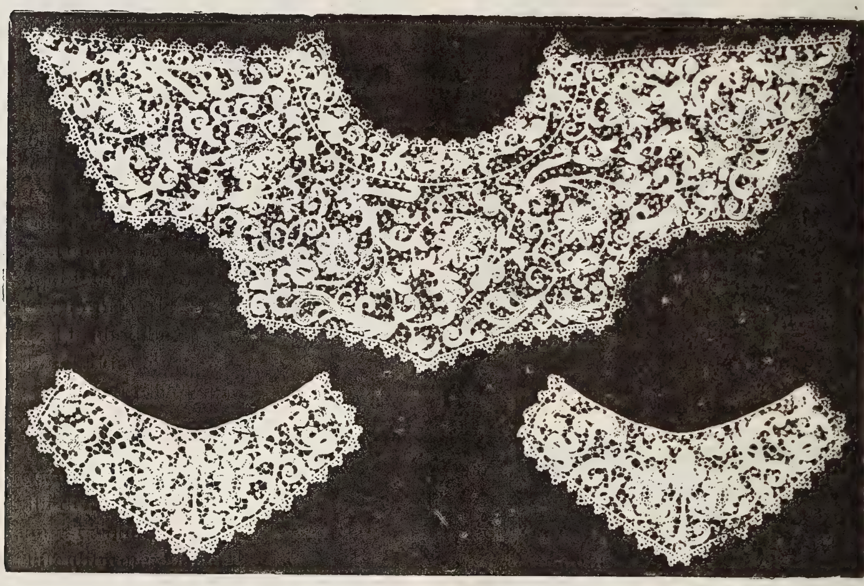
Much of the Carrickmacross lace consists of patterns cut out of muslin or cambric. Here (8) is the corner of a handkerchief made from an old design. Here (9) is an ornament for the front of a lady's dress, of similar work. This was done from a well-designed pattern, but through want of close and careful supervision the spirit of the design has been quite missed. This class of work is applicable to heavier material. Mrs. Alfred Morrison

selected a design for a parasol cover (10) which should be wrought in fine linen. Here is the result. For still stouter material we had a design made for a sofa-back cover (11). Her Majesty the Queen graciously gave the order to have this carried out at the Bath and Shirley schools, Carrickmacross.

Besides the cut linen and muslin work of Carrickmacross, there is the *appliqué* Carrickmacross lace. The foundation is net, as in the Limerick lace. The ornamentation consists of bits of cambric stitched to it, intermingled with chain-stitch embroidery. Here (12, 13) are specimen borders designed by Miss Anderson of Cork, and worked at the Bath and Shirley schools, Carrickmacross.

14. The Marchioness of Londonderry gave an order for a flounce of such work, desirign that willow leaves should be introduced into the design. Prizes were offered in competition for the design, and her Excellency selected that from which the specimens now shown were executed.

15. One of the latest experiments in this class of work is for a curtain. The pattern was adapted by Miss Anderson, of Cork, from an old French brocade. The specimen before us was worked at the Convent of Mercy, Kinsale.



CRCCHET WORKED AT NEW ROSS, UNDER THE DIRECTION OF THE CARMELITE CONVENT, NEW ROSS, CO. WEXFORD.

16. Delicate needlepoint laces in the style of the 16th century, Italian patterns, are made by workers at Cappoquin, under the direction of Miss Keane. Here are a few samples of their work. For the most part, the designs have been taken from Vecellio's pattern book, published in the 16th century.

Turning now to crochet (17), the first specimen displays the sort of design which has been employed for a long time in Ireland. The shapes are not beautiful if taken one by one, and the arrangement of them does not display ingenuity. Other typical patterns are shown in these two collars. (18) Here again the details are rudely drawn and constructed, though the decorative intention is more ambitious than that of the first crochet specimen. (19) The next slide exhibits an advance in pattern making. The upper collar and cuffs are simple in design, but the repetition of the little devices in them produces an effect of lightness and regularity which is pleasing. The lower set of collars and cuffs is made from a well thought out design, but the limitation in making crochet prevented the design from being so produced as to convey all the desired effect. (20) Here are some borders from fresh designs. These specimens (19 and 20) were made by workers supervised by the Carmelite Convent at New Ross.

21. Here are some more pieces of crochet work from new designs. The designs were made by Mr. Holland, and then worked out under his direction for Messrs. Dwyer, of Cork. (22) These again are crochets made for Messrs. Dwyer; the patterns for the lower borders were adapted by Mr. Holland from early Italian reticella laces.

An effective pattern was designed by Mr. Murphy, the master of the Waterford School of Art, and experiments tried with it in crochet by the Carmelite Convent at New Ross. It is intended for the panel of a lady's dress. This (23) is the upper portion of the panel, and the next slide (24) shows us the lower half of it.

24. An experiment in interchanging crochet with linen for furniture purposes was tried at New Ross, and a more or less promising result was obtained, as here.

From crochet we pass to needlepoint laces. These are of two classes, one the raised lace, an adaptation from the heavy Venetian and French laces of the time of Colbert; the other, flat needlepoint lace, in which the texture is finer, and resembles that of the late 17th and 18th century needlepoint laces.

26. Here are three pieces of raised lace from New Ross.

Next comes a panel (27) for a lady's dress, also of New Ross work. This has been made for Mrs. Alfred Morrison. The slide before us is of the upper half of the panel, and here (28) is the lower portion of the panel.

29. Here are two borders of similar heavy needlepoint lace, made by workers under the direction of Miss Maclean at Innishmacsaint. The patterns were designed and drawn out by Miss Perry, of the Cork School of Art, who most successfully took her ideas from Italian laces of the same class.

Characteristic of designs, which have been largely used for flat needlepoint lace in Ireland, is this corner of a handkerchief (30). The flowers are cumbersome and awkward. (31) Here are specimens of similar rude design.

32. To effect a change, we got the workers under the Presentation Convent, at Youghal, County Cork, to make some bits from new patterns. Those in the two upper pieces were designed by Miss Julyan, of the Dublin School of Art; whilst the two lower pieces are from designs by Mr. Hayes, of Limerick. The third specimen in this series is of very remarkable quality in daintiness of work. (33) Quite recently Mrs. Alfred Morrison has ordered a fan of flat needlepoint lace from Youghal. It was designed by Miss Julyan, and has only been completed within the last few weeks. The variety of ornamental devices, the accuracy with which the curves have been reproduced, and the regularity of the hexagonal or honeycomb grounding are, I venture to think, admirable in all respects.

The two last slides I have to show are from a new sort of needlepoint lace made at the Convent of Poor Clares, Kenmare. (34) Although the larger part of this collar and plastron are of the daintiest flat needlepoint work, some of the leading lines are of delicate raised work. One of the nuns at the convent made the design for this set, which was worked for Mrs. Alfred Morrison. The strenuous and well-sustained endeavours of the Kenmare nuns to encourage the lace-makers under their direction to press forward in perfecting their work, together with the untiring zeal of the nuns themselves to advance in the study and composition of ornament, are worthy of the highest commendation.

35. The last specimen is of Kenmare needlepoint lace. It is merely an experimental portion of a handsome flounce, designed by Miss Julyan, of Dublin.

Whatever may be said, these specimens demonstrate an activity in making new designs, and in improving the quality of make of Irish laces. Almost all the designs we have seen were made by Irish men and women. There is a variety of styles in them, the sum total of which can be classed as a national style. It is, I think, more promising for the future than the more limited and ruder compositions which, as establishing a national style, have not sufficed to keep the industry in a flourishing condition.

Years ago, the organisation in Dublin and Belfast of normal lace schools was attempted- but did not succeed. Surely a better fate seems to be in store for the numerous lace-making schools, and their drawing and pattern-making classes, which the convents have chosen to call into existence in various localities.

The maintenance of an industry like this lace-making depends naturally upon enterprise in developing it, and upon the public demand for its productions. If the demand from various causes is precarious, the man of business is not much tempted to foster the trade. All sorts of incidents give rise to this precariousness. The public, as a rule, will, I

believe, pay for a good piece of work so long as the price is not constantly varied. Prices for Irish laces have undoubtedly varied very much. Sometimes this has been due to inexperienced vendors, like convents and private individuals, who have paid, to the lace-makers, wages without reference to the commercial value of the work in the market; sometimes it has been due to an overstocking of the market with poor goods; and sometimes to a greedy grasping for a disproportionately high profit.

The examples seen this evening may, I hope, lead to a conviction that, in spite of many drawbacks and difficulties, the Irish lace industry is able to supply a great variety of pretty things, and, indeed, of beautiful works of art. But this is only possible, I think, when the direction of the lace-makers, locally, is thoroughly undertaken. With kindly interest, amateurs and philanthropists have often assumed to discharge the duty of competent direction. They have sometimes succeeded, and sometimes have created misapprehensions. But, apart from this, individual amateur direction has an inherent defect. The person exercising it may leave the locality without arranging for the direction of the labour to be continued in a consistent manner. Again, amateur direction has tended to relieve the man of business from locally directing the industry; so that between the effort on the one side, and no effort on the other, the lace-makers have often had to grope their way as they could. Where there are convents which choose to take up the work of supervision in a thorough manner, the chances of keeping the industry in a lively condition seem to be promising. Where there are no convents to do this, possibly small local committees might be able to keep up an effective and continuous supervision over the industry.

There is no doubt that, as a body, Irish lacemakers have experienced bitter disappointments, which have resulted as much from absence of professional direction and from imperfect direction as from the erroneous idea they have been led to entertain of their independent ability to compete with the supervised lacemakers in other countries. The more, then, that the defects of the industry, and the difficulties in administering it, can be understood, the better I think will be the prospect of raising it to a higher level than the one it occupied some few years ago, and than the one to which present efforts have lifted it.

List of Specimens of Irish Lace Exhibited to Display the Employment of New Designs.

Limerick Lace (Tambour work).

1. Flounce worked at Mrs. R. Vere O'Brien's school, Limerick, from a design by Miss Emily Anderson, School of Art, Cork.
2. Set of trimming borders worked at the St. Vincent's Convent, Cork, from designs by Miss Emily Anderson, School of Art, Cork.
3. Insertion and border worked with silks, at Mrs. R. Vere O'Brien's school, Limerick.

Two borders worked under direction of nuns at the Convent of Mercy, Kinsale, from designs by students of the Art class at the convent.

4 & 5. Flounce and borders worked with silks, under the direction of the Convent of Mercy, Kinsale, from designs by Miss Brophy, London.

6. Flounce and border worked under the direction of the Convent of Mercy, Kinsale, from designs by Miss Emily Anderson, School of Art, Cork.

Carrickmacross Appliqué Lace.

7. Insertion and border made at the Bath and Shirley Schools, Carrickmacross, Co. Monaghan, from designs by Miss Emily Anderson, School of Art, Cork.
8. Two borders and insertion made at the Bath and Shirley Schools, Carrickmacross, Co. Monaghan, from designs by Miss Emily Anderson, School of Art, Cork.

Needlepoint Lace (raised lace).

9. Three specimens worked under the direction of Miss MacLean, Innishmacsaint, Lough Erne, Co. Fermanagh. The two borders are from designs by Miss Perry, of the School of Art, Cork. The centre piece is made from a design by Mr. T. Scott, of the School of Art, Cork, for Mr. Ben. Lindsay, of Dublin.
10. Specimens worked under the direction of the Carmelite Convent, New Ross, Co. Wexford, from designs by Mr. Sam. Murphy, Master of the School of Art, Waterford.
11. Three specimens worked under the direction of the Carmelite Convent, New Ross, Co. Waterford. The upper border is from a design by Miss Perry, of the School of Art, Cork. The centre piece is from a design by Mr. Michael Hayes, Limerick. The lower specimen is from design by one of the nuns in the Carmelite Convent, New Ross.

Needlepoint Lace (in the style of Reticella and Early Italian Lace.)

12 & 13. Borders and doyleys worked at Cappoquin, Co. Waterford, under the direction of Miss Keane, from designs adapted by her from a

Cesare Vecellio's pattern-book (Venice, 16th century).

Flat Needlepoint Lace.

14. Borders worked under the direction of the Presentation Convent, Youghal, Co. Cork. The two upper ones are from designs by Mr. Michael Hayes, Limerick. The two lower ones are from designs by Miss Julyan, Mistress of the School of Art, Dublin.
15. Part of a flounce, of flat and slightly raised work, made under the direction of the Convent of Poor Clares, Kenmare, Co. Kerry.

Pillow Lace (appliqué to net) Border.

16. Border made under the direction of the Convent of Mercy, Parsonstown, from a design by a nun in the Convent of Poor Clares, Kenmare, Co. Kerry. (The border below it is of silk Limerick lace, made at the Convent of Mercy, Kinsale, Co. Cork.)

Crochet.

17 & 18. Borders and trimmings made for Messrs. Dwyer, of Cork, by workers in the neighbourhood of Cork, under the direction of, and from designs by, Mr. Michael Holland, of Cork.

19. Specimens of Silk Crochet (Borders, Plastron, and Collars), made for Messrs. Dwyer, of Cork, by workers in the neighbourhood of Cork, under the direction of, and from designs by, Mr. Michael Holland, of Cork.

20. Three borders made by workers under the direction of, and from designs by, members of the Carmelite Convent, New Ross, Co. Wexford.

21 & 22. Collars and cuffs made by workers under the direction of the Carmelite Convent, New Ross, Co. Wexford.

23. Two borders made by workers under the direction of the Carmelite Convent, New Ross, Co. Wexford.

DISCUSSION.

Mr. G. T. KNIGHT (secretary of the Society for Promoting Industrial Villages), was pleased to hear that so much practical work had been done in connection with this indnstry. The attempt to form local committees was just the work which the society he was connected with was engaged in, and he knew there was a demand for these little industries all over Ireland, and England too. If anything could be done to encourage the formation of little factories or workshops where these industries could be carried on, it would be as useful a work as anything the Society of Arts could engage in. The great difficulty occurred with the question of disposing of the products of these industries, but there was a movement on foot in connection with the co-operative productive societies for establishing a London depôt for disposing of the various articles manufactured by these co-operative societies in the different districts. Mr. Hodgson Pratt had started the movement, and it would be well if this paper led to some recognition of it as an important aid in the disposal of these products.

Miss BLACKBURN said it had been of great interest to her to hear of the progress made in the convent schools, and she thought the more the power of the convent to teach the public was recognised and developed the better. They were the great centres from which all kinds of industrial work could best be taught to the people. The nuns seemed to have much zeal and a great desire to keep in touch with the movements of the day, and it was very gratifying to find how successful they had been. The contrast between the clumsier early patterns and the later ones was very marked. Where there were convenient centres no doubt they would come in direct contact with the regular dealers in lace, and there would not be much difficulty in finding a market. She hoped more from association with the large firms than from any society formed for the purpose of showing co-operative products.

Miss CATHERINE DREW said the great improvement in the lace work was due to the knowledge and care bestowed both in the design and execution, and she thought the first thing now required was to educate milliners, dressmakers, ladies' maids, and ladies themselves in the use of lace. Every kind of lace required a different treatment. Limerick lace could not be put on a dress in the same way as needlepoint. Many ladies had collections of Irish lace, but did not know how to make it up; and if there were some centre in London where an exhibition could be established, showing how the different kinds of lace could be arranged in an artistic way, it would do much to promote the sale of this beautiful work.

The CHAIRMAN, in proposing a vote of thanks to Mr. Cole, said he much regretted that the Duke of Abercorn was not able to be present as he had intended. The lesson they had received showed the advantage of technical education in a very remarkable way. There were people with the power at their fingers' ends to produce the most beautiful workmanship, and yet they failed for want of that knowledge of design which was the true foundation, and which alone would make this work popular in the eyes of those who were capable of judging between a good design and a bad one. Nothing was more valuable than the work which had been done by Mr. Cole in going about instructing the various centres how they might best set about designing this work which cost so much labour, and which labour was entirely thrown away unless the people worked on a sound basis. Technical educa-

tion had been introduced in every other kind of work, and it was time it should be introduced in this also; and the people should be taught to undertake the study of design as one of the main subjects of their education, and in particular the elements of design as adapted to this particular kind of work. No one could have seen the samples exhibited without noticing the immense advance made in those designed with care after instruction as compared with the earlier patterns. The remark made with regard to some of the patterns was most apposite. You could see at once that a leading mind was wanted to direct the worker. It occurred to him, as an architect, that many of these designs were based on architectural forms to be found in books, which gave the beautiful scrolls and delicate work introduced by the artists of old times in the construction of buildings, friezes, and other ornaments of that description. The attempt at the honeysuckle ornament failed entirely for want of knowledge of what the true Grecian ornament was. Mr. Cole had drawn attention to the clumsy way in which the ornament was drawn, but he did not call it by its name, possibly because he did not recognise it. But the honeysuckle ornament itself was a beautiful thing, and variations of it were to be found in every form of art. Anyone who glanced through Mr. Owen Jones's beautiful book, "The Grammar of Ornament," would find that the idea ran through all kinds of art work. There was a difference between this and ladies having dresses with the five orders of architecture, as designed by Inigo Jones; but that sort of taste was quite gone now, and people understood that the designs made for any particular purpose must be suitable for that purpose, and that it would not do to support a lady with the five orders of architecture. The paper had been most interesting and instructive, and the beautiful slides with which it had been illustrated enabled them to judge of the different kinds of work better even than by seeing the specimens themselves. They would all agree in hoping that the time would come when Ireland would be at work at something more profitable than the agitation in which she had been lately engaged.

The Countess of Aberdeen seconded the vote of thanks. She had some knowledge of what Mr. Cole had been able to do in Ireland for the lace-making industry; and the best thanks of all friends of Ireland were due to him for his untiring efforts, and for the tact which had enabled him to persuade the workers to act in co-operation with him.

The vote being passed unanimously,

Mr. A. S. Cole, in reply, said he might mention one or two facts which had come to his knowledge since writing the paper. First, with regard to crotchet-work; one who was engaged in this work called on him last week, and showed him a variety of new pieces of crochet of such a character that their success was a moral certainty. They were in many instances better than similar crochet-work made in France or Bavaria. The producer courted competition, and did not in the least want to hear of anything in the nature of protection for his branch of industry. He preferred to rely on the success which he felt certain he was going to achieve for the obvious superiority of this new Irish crochet which he was about to introduce. He considered that he was about to bring his work to this perfection, in consequence of instructions in geometrical and other drawings which he had received at the School of Art which he attended. He was a busy man in the day time, but he made a point of attending the evening classes three or four times a week. The second fact which he had heard within a day or two from a correspondent in Ireland, was that a well-known Dublin dealer was enlarging the scope of his operations, and instead of restricting them to the north was getting down to the south, and was now negotiating with one or two of the southwesterly lace centres supervised by the convents. He could not help thinking that the intervention of commercial ideas into these convents would be of the utmost value in securing the fullest employment for the workers; and, at the same time, the men of business would no doubt be all the better for being brought under the influence of the convent. The co-operation of the two would tend to improve both the quality of workmanship and design, and thus more saleable lace would be produced.

Miscellaneous.

THE CULTIVATION AND PREPARATION OF PRUNES IN FRANCE.

The introduction of prunes into France is attributed to the Crusaders, says the United States Consul at Bordeaux, and if tradition is exact, this valuable fruit was first cultivated in the south-west of France by the inmates of a convent near Clairac. In travelling from Avignon to Fumel, through the valley of the Lot, fertile plains are seen covered with plum trees, which furnish the famous *prunes d'Ente* and *Robe-Sergent*, these being exported to the remotest corner of the commercial world. The plum tree does not confine itself to this particular district of France, but it is profitably cultivated in the valley of the Loire, the departments of the Garonne, Dordogne, Tarn, and Aveyron. The well-known brand, called Tours' prunes, comes from the orchards of the Loire. Lorraine produces a variety called Quetsche, one of the best for ordinary preserves. The prune tree thrives best in clayey calcareous soil, and does not exact for its roots a loam of profound depth. Land

adapted to the culture of the vine is also partial to this tree. In many localities these two valuable products are cultivated together, as the broad leaf of the vine is especially useful in protecting the roots of the tree from the intense heat of summer. When the prune is ripe, it is covered with a sort of glaucous powder called flower, which greatly adds to its value as a table fruit. The fruit is usually gathered after the heat of the day has dissipated the humidity of the night, and when possible, straw is spread beneath the trees to prevent the fruit coming in contact with the earth. Only such fruit as readily falls when the tree is slightly shaken is gathered. As soon as harvested, the fruit is taken to a building where it remains for a few days to complete maturity. Prunes are subjected to not less than three, and frequently to four, distinct cookings before being pronounced ready for market. The first two preliminary cookings have for their object the evaporation of water contained in the fruit, and preparation for the final cooking, which dries the fruit and imparts a certain brillancy much sought after by buyers. In several districts of France most primitive means are practised in curing the fruit for market. In Provence freshly gathered fruit is plunged into pots of boiling water where it remains until the water again arrives at boiling point. It is then removed from the boilers, placed in baskets and gently shaken until cool, when it is placed on long trays and exposed to the heat of the sun to complete dessication. At Digne, the prunes are not gathered until completely matured. Women peel the fruit with their nails to avoid injury to the soft pulp. The fruit is strung upon small twigs and in such fashion as not to touch; these sticks of prunes are stuck into straw frames, which are suspended in the sun until the prunes easily detach themselves from the stick; the pit is then removed, the fruit placed upon trays exposed to the sun, and when thoroughly dessicated packed for market. In the departments of Indre-et-Loire and Lot-et-Garonne, immense ovens, specially constructed for prune cooking, are used. Most prunes are subjected to a preliminary washing to free them from dust or sand. After washing, the fruit is exposed to the sun or air on beds of straw, or on the trays on which it is cooked, to rid it of all humidity. When dry, it is spread in a single layer on the tray and at once submitted to the oven. The trays used are made during the winter months by peasants; they are clumsy and cumbersome, and very primitive in their construction, only consisting of a frame to which is fastened a wicker-like bottom fashioned from rushes or willow twigs. They hold from twelve to eighteen pounds of green fruit, representing about four to six pounds of prunes. Care is taken in preparing the oven for the first cooking that the degrees of heat shall not exceed 50 degrees Centigrade, and in the second, 70 degrees. After each cooking, which occupies about six hours, the fruit is removed from the oven and exposed to the air. When the prunes are cold, they are carefully turned by women specially charged with this duty. They avoid disturbing the fruit while it is warm, as the touch renders it glutinous and prevents the fruit from congealing. The third cooking is performed at a temperature of 80 to 90 degrees, and occasionally at 100 degrees. After the third cooking the prunes are sorted, and such as are found imperfectly cooked are again submitted to the oven. The degree of perfection in cooking is obtained when the fruit presents a dark purple colour, solid and brilliant surface, malleable and elastic to the touch, and when the kernel is well done and intact in the shell. When these conditions are not obtained, the kernel ferments, and alters the entire prune, which very soon becomes mouldy and worthless. Prunes are divided into nine categories, and are classified as follows:—No. 1 represents 90 to 92 to the pound; No. 2 represents 80 to 82 to the pound; No. 3 represents 70 to 72 to the pound; No. 4, 60 to 62; No. 5, 55 to 56; No. 6, 44 to 45; No. 7, 40 to 41; No. 8, 34 to 35; and No. 9 represents 30 to 31 to the pound. When ready for exportation, the fruit is pressed flat between two cylinders covered with india rubber, and then packed into cases by a special machine called a packer. Many dealers still perform this operation in the primitive manner of foot pressure. Bordeaux is the principal centre of their industry, which is yearly increasing. Besides the large amuont of prunes exported to European countries by rail, there are, says Consul Roosevelt, about one hundred vessels annually leaving the port of Bordeaux loaded with this produce. In the beginning of the prune industry many devices were employed for their proper conservation. The first ovens were very primitive, and the work of preparing the fruit for market laborious. At present there are many different kinds of ovens in use, possessing more or less distinct features, but almost the same in general principles, the most generally used are the *Bournel* and the *Marletean* ovens. The only ovens in use are of French manufacture.

SALT IN CHINA.

Consul Jones, of Ching Kian, in his last report states that Chinese salt is produced in the flat marshy country on the east coast of Kiang-Su province. These marshes cover an area of several hundred square miles, and there are thirty-six principal salt flats. It is all produced by evaporation in flat pans heated by burning dry seeds and brushwood, and is of two qualities only, the upper layer, a brownish white, the superior, and the lower a dark brown, "the people's salt." It is principally evaporated in the autumn and spring. The cost of production is two cash per catty (1,000 cash are equal to 5s. 10d., and the catty is equivalent to $1\frac{3}{4}$ lbs. avoirdupois). The salt is sold to the merchants at a fixed rate of three cash per catty, and the duty (*lekin*), and official charges thereon amount to about forty-five cash per

catty. It is retailed at from fifty to fifty-two cash per catty according to locality. Salt cannot be consumed or sold in the provinces where it is produced. This law is with a view of increasing the emoluments to the Government officials. Kiang-Su salt is exported principally to the provinces of Anhui, Kiang-Si, Hupeh, and Honan. Evaporated salt is produced also in the provinces of Chê-Kiang, Szechaen, Kuantung, and Shantung. Ching Kiang receives its salt from Chê-Kiang, as it is nearer and the transportation is cheaper. Salt is exported in junks of from 400 to 1,000 piculs (the picul is equivalent to 133 pounds) carrying capacity, and is packed in straw bags of 84 catties weight. Merchants desiring to engage in the salt business must produce the best references at the salt commissioner's yamen, at Yangchau. They must further deposit with this official a sum proportionate to their proposed transactions, which deposit, in each case, amounts to several thousand dollars. The permits to trade are drawn by lottery; in case of blanks the deposit is refunded. Each permit is for eight hnndred pounds of salt. The principal or official salt merchants obtain their licenses from the board of revenue at Peking, and they hold during their lives. The Imperial Treasury at Peking derives a large revenue from the salt trade, which is one of its chief dependencies. The manufacture and the traffic give employment to many thousands of people. The wages of the people employed on the junks in the transportation of salt are between nine and twelve shillings per month. The captain or chief man of the boat receives about seventeen shillings per month. The workmen at the salt flats receive from twelve to sixteen shillings a month, the employers providing them with rice, which is their chief food. In some cities salt is peddled about the streets by blind men, who have the monopoly of this business. No one is allowed to interfere with them or enter into competition. Consul Jones, in conclusion, says that although he has requested iuformation as to the quantity of the annual product of salt from all the works, or any of them, he has been unable to obtain it, but he is of opinion that the quantity and amount of sales must be very great to supply the vast population, to create such a revenue, and to enable all those concerned in the management and trade to grow so rich.

INDIA-RUBBER TRADE OF UPPER BURMAH.

From a report which has been made by the political officer at Bhamo, on the india-rubber trade of the Mogoung district, it appears that this article was first exported from Upper Burmah in 1870, and until 1873 the trade was free to all. Since the latter year, however, the forests have been worked under the monopoly system, five Chinese firms being the joint concessionaires, two supplying the money and three superintending the work. The price ranged from 60,000 to 90,000 rupees per annum. The forests occupy an extensive Kachin district north of Mogoung, and stretching east across the Chinese border. The Kachins are exceedingly jealous of interference with their trees, and although at first they made the mistake of over-bleeding them, they are more careful now. Mogoung is the head-quarters of the trade; four-fifths of the yearly supply is brought in there by Kachins in the employ of Chinese, the remaining fifth being purchased in the district by Chinese agents of the lessees. The practice is for the Chinese manager in Mogoung to make liberal advances to the Kachins, to defray expenses during the collecting season; when the rubber is brought in, the refund is made by selling the rubber to the manager at half the market price. The travelling Chinese agents, who also collect india-rubber, merely travel from place to place, buying such quantities as the Kachins offer, but as the latter have no standard weights, they are usually cheated to the extent of about 70 per cent. The profit on this difference of weight more than pays the expenses of the agents. In most cases rubber is the subject of certain transit charges through the Kachin districts, *tsawbwas* or local chieftains levying a certain toll—perhaps two or three balls out of a hundred. Whatever the toll, the Chinese manager and Kachin owner bear the loss in equal shares; but the latter is amply compensated by being housed and fed at the expense of the Chinese during his stay in Mogoung.

POPULATION OF SWEDEN.

According to the *Befolkningsstatistik* recently published by the Swedish Government, the population of Sweden at the end of 1886 numbered 4,717,189 persons, of whom 825,388 inhabited the towns. The following statement shows the numbers of the population in each of the years, from 1881 to 1886:—

1881	4,572,245
1882	4,579,105
1883	4,603,585
1884	4 644,448
1885	4,682,769
1886	4,717,189

The increase, though steady, is slow, amounting to about 35,000 annually. The population of the principal towns of Sweden is as follows:—

Stockholm	223,000
Gothenburg	93,000
Malmö	45,000
Norrköping	29,000
Gefle	21,000
Uppsala	21,000
Karlskrona	19,000
Helsingborg	16,000

Lund	15,000
Orebro	14,000
Kolmar	12,000
Linköping	12,000
Landskrona	12,000
Sundsvall	11,000

There are 15 towns containing more than 10,000 inhabitants; 20 containing from 5,000 to 10,000; 26 from 2,000 to 5,000; 19 from 1,000 to 2,000; and 11 with a population under 1,000.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings at Eight o'clock:—

MARCH 6.—"Arc Lamps and their Mechanism." By Prof. SILVANUS P. THOMPSON. W. H PREECE, F.R.S., will preside.

MARCH 13.—"Aluminium and its Manufacture on the Deville-Castner Process." By WILLIAM ANDERSON, M.Inst.C.E. Prof. SIR HENRY ROSCOE, F.R.S., will preside.

MARCH 20.—"Motor Trials of the Society of Arts, 1888." By Prof. A. B. W. KENNEDY, F.R.S.

Papers for which no dates have as yet been fixed:—

"The Sanitary Functions of County Councils." By SIR DOUGLAS GALTON, K.C.B.

"Automatic Selling Machines." By J. G. LORRAIN.

"Secondary Batteries." By W. H. PREECE, F.R.S.

"The Use of Spirit as an Agent in Prime Movers." By A. F. YARROW.

FOREIGN AND COLONIAL SECTION.

Tuesday evenings, at Eight o'clock:—

MARCH 26.—"Borneo." By ROBERT PRITCHETT.

APRIL 2.—"The Argentine Republic." By F. K. SMYTHIES.

APPLIED ART SECTION.

Tuesday evenings, at Eight o'clock:—

MARCH 19.—"The Art of the Jeweller." By CARLO GIULIANO. SIR GEORGE BIRDWOOD, K.C.I.E., C.S.I., will preside.

APRIL 9.—

MAY 14.—"Venetian Glass." By DR. SALVIATI.

INDIAN SECTION.

Friday evenings, at Eight o'clock:—

MARCH 8.—"The Present Condition and the Prospects of Indian Agriculture." By PROF. ROBERT WALLACE. The DUKE OF BUCKINGHAM, G.C.S.I., will preside.

MARCH 29.—"The Progress of the Railways and Trade of India." By SIR JULAND DANVERS, K.C.S.I. SIR GEORGE BRUCE, P.Inst.C.E., will preside.

MAY 3.—"The Karun as a Trade Route." By MAJOR-GENERAL SIR R. MURDOCH SMITH, K.C.M.G.

MAY 24.—"Indian Wheats." By JOHN MCDOUGALL.

CANTOR LECTURES.

The following courses of Cantor Lectures will be delivered on Monday evenings at Eight o'clock:—

WALTER CRANE, "The Decoration and Illustration of Books." Three Lectures.

LECTURE I.—MARCH 4.—Art always the mirror of the life and thought of its age—The modern book and newspaper developed from primitive picture-writing and hieroglyphic—The two sides of art—Imitation and invention—Illustration and decoration, sometimes distinct, sometimes united — Both decorated and illustrated books divisible into two great periods—I. the MS. period, and II. the period of printed books—Examples of both illustration and decoration throughout both—Early examples from the Book of Kells, from remarkable illuminated MSS. of the 10th, 11th, 12th, 13th, 14th, and 15th centuries, in the British Museum—Spacing of the page—Treatment of the text and margin—Origin of the coloured initial letters in liturgical books—Their decorative value—Harmony of text illustrations and ornaments in illuminated MSS.—Approach of the new epoch of classical learning and printed books.

LECTURE II.—MARCH 11.—Examples of transition—Illumination with printed text—Engraved ornaments and outline pictures intended for illumination—Block books—Examples from the British Museum—The Mazarin Bible—The Mentz Psalter, 1457—The first example of colour printing—French books of Hours by Pigouchet, Hardouyn, and Kerver—Effect of the classical revival upon book decoration and illustration—Hypnerotomachia Poliphilo, Aldus, 1499—Examples from German, Italian, French, and English printed books in the British Museum—Remarks on their decorative and illustrative value—Development of draughtsmanship and graphic power—Albert Dürer—Hans Holbein—Examples from their book designs—Printer's marks—Emblem books—Alciati—Giovio—Witney—Quarles—The love of figurative art—Use of copperplate—Decorative book illustration—Encyclopædic books—Herbals—Matthioli—Gerard—Decline of beauty and vigour in design and ornamental sense towards the close of the 16th century.

LECTURE III.—MARCH 18.—Of book illustration and ideas of decoration from the 16th to the 19th

centuries—Decline of inventive and applied design—Injurious effects of Renaissance traditions—Use of copperplate—Inharmonious combination of with type—Examples—Later designers and illustrators—Hogarth—Stothard—Flaxman—Examples from their works—William Blake—The Book of Job—Benick—Revival of wood engraving as applied to illustrative art—Calvert and other Illustrators—Turner—Steel vignettes—Book illustrators of 40 years ago—W. J. Linton—Effect of the pre-Raphaelite movement—Rosetti as a book illustrator—Modern gift-books—Children's books—Development of—Japanese printed books—Influence of—American development of wood engraving, and American ideas of design and page decoration—Vedder's Rubaiyat of Omar Khayyam—Influence of the photograph—General remarks, and conclusion.

C. V. Boys, F.R.S., "Instruments for the Measurement of Radiant Heat." Four Lectures.

March 25; April 1, 8, 15.

H. Graham Harris, M.Inst.C.E., "Heat Engines other than Steam." Four Lectures.

May 6, 13, 20, 27.

MEETINGS FOR THE ENSUING WEEK.

Monday, March 4...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. Walter Crane, "The Decoration and Illustration of Books." (Lecture I.)

Farmers' Club, Salisbury-square Hotel, Fleet-street, E.C., 4 p.m. Mr. F. Street, "Protection."

Royal Institution, Albemarle-street, W., 5 p.m General Monthly Meeting.

Engineers, Westminster Town Hall, S.W., 7½ p.m. Mr. George R. Strachan, "The Construction and Repair of Roads."

Chemical Industry (London Section), Burlington-house, W., 8 p.m. Discussion on "In what direction is State Aid needed to assist Technical Education in Chemistry?"

Medical, 11, Chandos-street, W., 8½ p.m.

Victoria Institute, 7, Adelphi-terrace, W.C., 8 p.m. Paper by Mr. H. Clarke.

London Institution, Finsbury-circus, E.C., 5 p.m. Mr. C. V. Boys, "Soap Bubbles, and what may be shown with them."

Tuesday, March 5...Royal Institution, Albemarle-street, W., 3 p.m. Dr. G. J. Romanes, "Before and After Darwin." II. "Evolution." (Lecture VII.)

Central Chamber of Agriculture (at the House of the Society of Arts), 11 a.m.

Civil Engineers, 25, Great George-street, S.W., 8 p.m. Adjourned discussion on Mr. Gisbert Kapp's paper, "Alternate-Current Machinery."

Pathological, 53, Berners-street, Oxford-street, W., 8½ p.m.

Biblical Archæology, 9, Conduit-street, W., 8 p.m.

Zoological, 11, Hanover-square, W., 8½ p.m. 1. Mr. Joseph S. Baly, "Descriptions of South American Coleoptera of the Genus *Diabrotica*." 2. Rev. H. S. Gorham, "New Genera and Species of Eastern Coleoptera of the Family *Telephoridæ*." 3. Colonel R. H. Beddome, "Descriptions of new Land-shells from the Island of Korar (Pelew group). 4. Mr. W. E. Hoyle, "The Anatomy of a Rare Cephalopod (*Gonatus fabricii*).

Wednesday, March 6...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Prof. Silvanus P. Thompson, "Arc Lamps and their Mechanism."

Geological, Burlington-house, W., 8 p.m. 1. Mr. G. W. Lamplugh, "The Subdivisions of the Speeton Clay." 2. Rev. R. Baron, "Notes on the Geology of Madagascar." 3. Prof. F. H. Hatch, "Notes on the Petrographical Characters of some Rocks collected in Madagascar by the Rev. R. Baron."

Entomological, 11, Chandos-street, W., 7 p.m.

Archæological Association, 32, Sackville-street, W., 8 p.m.

Obstetrical, 53, Berners-street, W., 8 p.m.

Civil and Mechanical Engineers, Westminster Palace Hotel, S.W., 7 p.m. Mr. E. A. Brayley Hodgetts, "Liquid Fuel."

Thursday, March 7...Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

Linnean, Burlington-house, W., 8 p.m. Rev. Geo. Henslow, "The Vascular System of Floral Organs."

Chemical, Burlington-house, W., 8 p.m. Ballot for the Election of Fellows.

London Institution, Finsbury-circus, E.C., 6 p.m. Mr. Carl Armbruster, "Modern Composers of Classical Song." II. Robert Franz.

Royal Institution, Albemarle-street, W., 3 p.m. Dr. Sidney Martin, "The Venom of Serpents and allied Poisons." (Lecture III.)

Archæological Institution, 16, Burlington-street, W., 4 p.m.

Friday, March 8...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Indian Section.) Prof. Robert Wallace, "The Present Condition and the Prospects of Indian Agriculture."

United Service Inst., Whitehall-yard, 3 p.m. Dr. G. Fleming, "Forage for Military Purposes."

Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting, 9 p.m. Prof. Oliver Lodge, "The Discharge of Leyden Jars."

Civil Engineers, 25, Great George-street, S.W., 7½ p.m. (Students' Meeting.) Mr. Charles F. Smith, "Notes on Mining in Spain, with special reference to the Lead Mines of Linares."

Astronomical, Burlington-house, W., 8 p.m.

Quekett Microscopical Club, University College, W.C., 8 p.m.

Clinical, 53, Berners-street, W., 8½ p.m.

New Shakspere, University College, W.C., 8 p.m. Mr. Sidney L. Lee, "An Elizabethan Publisher, Edward Blount."

Saturday, March 9...Physical, Science Schools, South Kensington, S.W., 3 p.m. Prof. Oliver J. Lodge, (1) "The Magnetic Optic Rotation by Transient Currents, with reference to the Time required for the production of the Effect;" (2) "An Electrostatic Field produced by varying Magnetic Induction;" (3) "Some Experiments allied to those of Hertz; (4) "The Velocity of Electric Pulses along a pair of Isolated Wires;" (5) "Sundry Laboratory Notes."

Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Lord Rayleigh, "Experimental Optics." (Lecture III.)

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FRIDAY, MARCH 8, 1889.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CANTOR LECTURES.

The first lecture of the course on "The Decoration and Illustration of Books," by Walter Crane, was delivered on Monday, the 4th inst.

The lectures will be printed in the *Journal* during the summer recess.

Proceedings of the Society.

THIRTEENTH ORDINARY MEETING.

Wednesday, March 6, 1889; William Henry Preece, F.R.S., in the chair.

The following candidates were proposed for election as members of the Society:—

Baillie, Alexander Francis, 13, St. Stephen's-road, Bayswater, W.
Chretien, George Thomas, 4, Russia-court, Milk-street, E.C.
Cox, Ebenezer John, 23, Albany-road, Harborne, Birmingham.
Hoyle, John, Cliff-house, Greenhithe, Kent.
Maryon-Wilson, Sir Spencer M., Bart., Charlton-house, Kent.
Regnart, Horatio Grece, Highgate-lodge, West-hill, Highgate, N.
Thrower, Alfred, 28, Albert-street, Regent's-park, N.W.

The following candidates were balloted for and duly elected members of the Society:—

Beale, Frederick, Gas Works, Beckton, E.
Butcher, William Deane, M.R.C.S., Clydesdale-villa, Windsor.
Griffith, Samuel Clewin, M.D., 45, Finsbury-square, E.C.
Hamilton, Thomas, 46, Parliament-hill, Hampstead, N.W.
Morse, Sydney, 4, Fenchurch-avenue, E.C.

The paper read was—

ARC LAMPS AND THEIR MECHANISM.

By Prof. Silvanus P. Thompson, D.Sc., M.I.E.E.

An arc lamp being an apparatus for transforming the electric energy supplied to it through the conducting wires into heat and light, it obviously cannot be expected to give a steady illumination unless it can be so arranged and operated that, in the first place, the rate at which it appropriates and transforms the electric energy is constant, and that, in the second place, the circumstances attending this transformation (in respect of the triple relation between the quantity of heat evolved, the degree of temperature, and the emissivity of the incandescent surface), also remain constant. The first of these two provisos relates to the operation of the system of lamps and dynamos (or other means of electric supply) acting conjointly; the second of them relates solely to the quality of the carbon pencils used as electrodes.

As the latter is a simple matter, it may be disposed of first. Suppose the pencils to be composed of a homogeneous carbon, the physical properties of which, such as hardness, specific thermal capacity, conductivity for electricity, conductivity for heat, emissivity, &c., are constant; also that they are cylindrical and of given diameter. Then it follows that if energy is being expended at a uniform rate in heating the tips of a pencil it will be maintained at a uniform temperature, and the amount of light emitted per square millimetre of the surface will be constant, and, as the section is constant, the rate of consumption constant, and the pencil homogeneous, the form once acquired by the incandescent tip (whether positive crater or negative peak) will remain constant. It may be remarked, in passing, that the researches of Captain Abney have shown that the white light of the incandescent carbon surface of the crater at the positive pole of the arc is always of precisely the same composition in respect of the relative proportions of waves of different colours.

This most important observation indicates beyond doubt that the temperature of the actual light-emitting surface is always the same. Indeed, this ought to be the case if the latent heat of vapourisation of carbon be a positive quantity. When the surface attains this temperature, volatilisation begins; and when so begun the temperature cannot rise further, any more than ice can be raised above its temperature of fusion. The limiting temperature of the voltaic arc is the temperature of volatilisation of the material of the electrodes. This is, in itself, a reason why the introduction of all known foreign substances whatsoever into the carbon pencils of the arc is found to lower its intrinsic brilliancy; for all known elements have a lower temperature of volatilisation, and all compounds are dissociated at arc temperatures.

If, then, we may assume homogeneity of the carbons to be used, the steadiness of the arc light will depend solely upon the maintenance of a steady rate of appropriating and transforming electric energy. How a want of homogeneity may be compensated for in the actual working of the lamp is a point reserved for consideration later.

The rate at which electric energy is appropriated from the wires, and transformed in the lamp into heat and light, always depends both upon the construction of the lamp and upon the conditions imposed upon the system of electric supply. This is a mere consequence of the fact, well known to every electric engineer, that the amount of electric energy per second appropriated by any electric device, motor, or accumulator, is itself the product of two quantities—the current, and the pressure (or potential) at which the current is supplied. To put the matter in electrician's language, the number of *watts* of electric energy per second appropriated by the lamp* is equal to the number of *ampères* that flow through it multiplied by the number of *volts* that may be applied as a difference of potentials between its two terminals. To keep constant the *product* of the ampères and the volts is the practical problem which the mechanism of the arc lamp must be designed to solve.

A point of much theoretical interest, and in reality of great practical importance, is the fact, long disputed, now established beyond question, that the arc itself does not act simply as an added resistance in the path of the current, but exercises also a counter-electromotive force, and tends to set up an opposing current. The apparent resistance of the arc resembles that of an electrolytic cell, or that of an electric motor when running, or, that of a thermopile when a current from an external source is passed through it. The current which flows through the arc arouses, by a species of polarisation, an opposing electromotive force. The simplest fact in proof of this is that, unlike any ordinary conductor, the apparent resistance of the arc is not proportional to its length. The apparent resistance of an arc two millimetres in length

* Strictly speaking, the actual number of *watts* utilised in the arc is somewhat less than the whole number received from the supply, as a portion of the energy is expended in passing the current through the regulating coils, and another portion is lost in consequence of the resistance offered by the pencils of carbon themselves, and is merely expended in warming them. We may calculate the former loss as follows:—Let E represent the whole number of volts from terminal to terminal, and let i represent the whole current supplied, then the whole number of watts supplied is Ei. Let the *ohms* of resistance of the regulating coils in the main circuit be called a, and that of the shunt coils be called b, that of the carbon pencils themselves, c, and that of the resistance coils sometimes used in the main circuit to steady the arc, r. Also, in the case where the lamp has a shunt circuit, let the portion of i which passes through the carbons be called i_1, and that which goes through the shunt, i_2; so that $i_1 + i_2 = i$. The losses are then as follows:—

ai_1^2 = watts lost in main-circuit coil;
bi_2^2 = $E^2 \div b$ = watts lost in shunt coil;
ci_1^2 = watts lost in warming carbon pencil;
ri^2 = watts lost in the resistance coil.

The resistance of carbon pencils is usually small, and may be materially reduced by a thin coating of copper. The carbons used in commerce (11 to 15 millimetres in diameter) vary from about 0·15 to 0·2 ohms per foot, if plain, and from 0·001 to 0·09 if coppered. Cored carbons have a higher resistance than uncored. Carbons cut from solid gas-coke have from five to twenty times as much resistance as those made by the usual modern processes. When lamps are run in series, the resistance offered by the pencils is of more importance; for example, a set of 50 lamps newly trimmed with long carbons may offer 25 ohms more resistance than when all the carbons have burned down short. The resistance, a, of the regulating coils that are in the main circuit differs in different lamps, but may be taken at from 0·05 to 0·2 ohms. The resistance, b, of the shunt coils is seldom less than 200 ohms, and may be as much as from 400 to 500 ohms. Of the volts, E, applied to the lamp only a part is utilised, the lost volts being accounted for by the resistances in the path of the current. If these are deducted from the applied electromotive force, there will remain a certain number of volts, which we may call e, which are available as a useful difference of potential at the arc itself. To measure e directly, one has only to apply a voltmeter, making the contacts of its two leading wires to the two carbons at points respectively just above and just below the incandescent tips. The watts actually utilised in the arc are then calculated as the product ei_1. As shown above, e is less than E, and, indeed, may be considerably less, the lost volts depending upon the resistances introduced, and on the current flowing through them. If E is constant, e will not necessarily be so, but will be very nearly if i is also constant. Also i_1 is less than i in all lamps that have a shunt regulating coil, but is not usually more than from 3 to 5 per cent. less than i, so that in the cases where i is kept constant, i_1 will be nearly so also.

between the carbon tips is not double that of an arc one millimetre in length, nor anything near double. The fairest way to investigate the matter is to make a series of experiments with arcs of different lengths, the current being independently so regulated as to be maintained of the same strength in each case. There appears to be a true resistance proportional to the length, and a back-electromotive force which in steady arcs, and with currents of from seven to fifteen ampères, appears to be about thirty-eight to thirty-nine volts. When the arc hisses, as often happens if the length of it be very short, the back-electromotive force fluctuates very much, but always drops to something under twenty volts. Except in the case of constant-current circuits, this causes a sudden increase of current when the lamp begins to hiss, and it may be noticed that the light, though unsteady during hissing, is brighter at the negative pole of the arc.

Hitherto all guesses as to the cause of this counter-electromotive force have been very vague, not to say wild. To account for thirty-nine volts of polarisation on any hypothesis that it is due to electrolytic or thermo-electric action, is to suggest causes which are, to say the least, wholly inadequate. The explanation which for the past two years I have been in the habit of suggesting to my students, and which has not been otherwise published hitherto, is as follows: — Every reversible phenomenon which the current can itself produce, and which requires an expenditure of energy for its production, necessarily implies the exhibition of a counter-electromotive force. One has only to look at the cases of the reversible chemical action in a cell, of the reversible magneto-mechanical action of a motor, the reversible heating effects of a thermo-electric junction, to comprehend this. Now the phenomenon of volatilisation is a reversible one: give to the solid carbon at its volatilisation-temperature the necessary latent heat, it is changed to vapour; take from the vapour its latent heat, it condenses back to solid carbon. The arc under normal circumstances is the seat of an actual evaporation of carbon at the positive pole, as well as of a combustion at both poles. So far as any data exist, it appears that the excess of carbon consumed at the positive pole by an ordinary continuous current, is about 0·5 grammes per ampère-hour. If we knew the latent heat of volatilisation of carbon per gramme we could calculate *à priori* the necessary minimum electromotive force at the positive pole, which would obviously represent the counter-electromotive force so far as it is situated at that point. With long arcs the excess of consumption of the positive pencil over that of the negative is both less and more regular than that which occurs with short arcs. With short arcs three other phenomena occur which are important in this connection. Firstly, the short arc is liable to whistle or hiss, giving evidence of instability; secondly, it frequently gives rise to "mushrooms," or irregular growths of carbon upon the apex of the negative pencil; thirdly, when it hisses the counter-electromotive force becomes very unsteady, but appears to have an average value about half that of the steady long arc. It is worth while to throw out the suggestion, that the condensation of carbon at the negative pole, in the short arc, is accountable for the change in electromotive force, and for the instability which manifests itself by the hissing sound.

Passing from these conjectures to the construction of lamps for the production of light by the arc, we are now prepared to lay down the points which must be provided for in every arc lamp. It must be emphatically pointed out at the outset that, as the performance of a lamp depends upon the conditions under which it is supplied with electric energy by the circuit, the design of the lamp necessarily also depends on those conditions. In the present state of the art of electric distribution we may classify the conditions of electric supply under the following heads:—

I.—Continuous Supply at Constant Potential.

In this case the arc lamps are arranged either simply all in parallel or in parallels containing two in series; the currents being divided by mains and branches to the lamps. At least 55 volts should be allowed between the mains for single arcs. Practice shows that arc-lamps in parallel burn more steadily if a resistance wire of ·25 to 1·0 ohm be included in the lamp circuit. Taking the back electromotive force of a steady arc at 39 volts, it is obvious that the excess of the volts at the mains over this represents the volts used in driving the current through the actual resistance in the main circuit of the lamp. This resistance consists of four parts—the true resistance of the arc itself, which may vary from $\frac{1}{10}$ to $\frac{1}{2}$ ohm; the resistance of the carbon pencils, which averages about 0·15 ohm per foot per plain carbons; the resist-

ance of the main-circuit coils, which varies in different lamps from 0·05 to 0·2 ohm; and the resistance of the wire introduced for steadying the lamp. In a ten-ampère lamp, working at 55 volts at the mains, 16 volts remain, after deducting 39 for the back electromotive force, and these 16 are approximately distributed as follows:—2 volts in the arc itself, 3 volts in the carbons (say 2 feet long in the total), 1 volt in the main coil, and 10 volts in the steadying resistance.

II.—Continuous Supply with Constant Current.

In this case the arc lamps are arranged in series, the whole of the current going from one lamp to the next, and returning to the dynamo after having traversed successively all the lamps. This is, *par excellence*, the arc light system of distribution, the parallel system at constant potential requiring heavier mains. As the lamps arranged in series tend to steady one another, it is not necessary to allow more than 45 to 50 volts per lamp, including the ordinary lengths of cable from lamp to lamp. From 5 to 10 ampères is the usual current for arc lamps in series.

III.—Alternating Supply at Constant Potential.

In this case also, the lamps are usually arranged as in the first case, the only difference being in certain structural details, such as lamination of iron cores.

IV.—Alternating Supply with Constant Current.

This case can hardly be said to be practical, though alternate current dynamos, capable of supplying 6 or 8 lamps in series, have been constructed in past years.

The supply systems, whether continous or alternating, must be assumed, for the purpose of this paper, to perform efficiently what they profess, namely, to maintain constant one of the two factors of the electric power which they supply to the distributing system. In each case it remains for the mechanism of the lamp to effect such adjustment as will maintain constant the other factor of the product. If the condition of supply is "at constant potential," then it is for the lamp itself so to adjust its carbons as to keep the current through the arc constant. If the condition of supply is "with constant current," then the lamp must adjust its carbons to maintain between them the requisite potential. Hence the differences which are necessary in construction between those lamps which are to work "at constant potential" (in parallel) and those which are to work with constant current (in series). These differences, as will now be shown, chiefly affect the "feeding" mechanisms of the lamp.

In discussing the necessary mechanisms of arc lamps, no further reference will be made to lamps of the Jablochkoff candle type, nor to those with abutment blocks of marble ("Sun" lamp, &c.), nor to the so-called incandescence-arc ("Semi-incandescent") lamps, nor to those with curved carbons (Heinrichs's type), nor yet to those horizontal carbons (De Mersanne's, Solignac's, &c.).

Necessary Mechanism of Arc Lamps.

[A.] *Driving Power.*—In every lamp some means or mechanism is required to propel the carbons toward one another as they burn away, gravity being by far the most common agency for doing this.

[B.] *Striking Mechanism.*—In every arc lamp it is requisite to provide a mechanism for bringing the tips of the carbon pencils into contact, and then parting them asunder to the requisite distance across which the arc or flame plays. If, as in most lamps, the carbons are in contact when the lamp is out of action, then a mechanism is required simply to part them as soon as the current is turned on. The operation of producing the arc by parting the carbons is known as "striking" the arc. The mechanism must be automatic, so as to come into action not only when the current is first turned on, but at any subsequent time if from any cause the arc fails. An adjustment, *b*, of the striking mechanism is also usually added to permit of regulation in the length of the stroke or initial distance between the poles.

[C.] *Feeding Mechanism.*—As the carbons burn away, one or both of them must be propelled forward to maintain the arc at its proper size. This action is called "feeding" the arc. This action ought to take place by small and imperceptible amounts, and as the rate of consumption of the carbons is continually varying, even with carbons of the best modern manufacture, the lamp must itself regulate the rate at which the pencils are propelled forward in automatic correspondence with the consumption for the time being. Further, since the presence of soft and more readily volatilised portions in the pencils seems to be unavoidable, provision ought to be made so that, whenever the pencil burns down to such a portion, causing a sudden increase in the volume

of the flame or arc—technically called a "blower"—the mechanism of the lamp ought at once automatically to draw apart the pencils to a slightly greater distance. A lamp which has a *retractile* motion in either its feeding or its striking mechanism is superior to one that has not, as it can be used with cheaper and less pure brands of carbons. An adjustment, *c*, for regulating the frequency or range of the feeding movements is usual.

[D.] *Replacement Mechanism.*—When the pair of carbon pencils has burned away, the lamp trimmer has to replace the stumps by a new pair of long carbons. In order to admit these, the carbon holders must be pushed apart to their widest extent. Special mechanical devices for allowing this motion to occur have to be provided in some forms of lamp, whilst other forms need no special device.

[E.] *Moderating Mechanism.*—To prevent the carbon from making too sudden motions, it is usual to add a moderating device, such as a dash-pot, or, in the case of those lamps in which there is a train of wheels, a fan or a governor.

So far, the devices enumerated have been such as are common to all classes of lamps. Those which follow are only required in particular types of lamp.

[F.] *Focussing Mechanism.*—In all those cases where it is desired that the luminous points should occupy a fixed position in space, some additional mechanism is necessary to make the arc lamp keep its focus. In lamps designed for the mere lighting of area, this is not important, and in the vast majority of these the upper carbon descends whilst the lower carbon (the negative) is fixed: the luminous point slowly shifting downwards as the carbons consume. All devices for causing the carbons to move forward at such relative rates as to keep an approximately fixed position for the arc will be discussed, together with their methods of adjustment, *f*, under the heading of focussing mechanism.

[G.] *Change-over Mechanism.* — Lamps that must run for many hours continuously must be supplied with two pairs of pencils, because it is neither practicable nor advisable to use pencils of extreme length. In the double lamps it is appropriate to provide such arrangements as shall cause one pair of pencils to come into operation first, and when these are consumed away, shall change-over the action, either by electrical or by mechanical devices, so that the second pair of pencils shall come into operation.

[H]. *Cut-out Mechanism.*—Lamps intended for series working must be provided with some contrivance to prevent the extinction of the whole series when from any cause there is a failure of the light in any one lamp. The usual device is a sort of automatic relay arranged in connection with each lamp, to come into operation in the event of its failure, the operation of the device being (1) to cut the faulty lamp out of circuit by simply short-circuiting it, or (2) to substitute for it a wire of suitable resistance, or (3) to replace it by an auxiliary lamp. The device for performing either of the two former operations is technically known as a "cut-out."

Supplementary Contrivances.

In addition to the eight distinct species of contrivances above enumerated, there are numerous details which might be further classified; such, for example, as devices for *clamping* the carbon pencils to their respective holders in true allignment; devices for raising and lowering the lamps. For these, however, there is no space. Neither is it possible to enumerate the devices which have been suggested [Staite, Siemens, Brockie, Andrews, Crompton, Swinburne, and others] for *compensating*, in lamps whose action depends on the weight of the descending carbon pencil and its holder, for the diminution of pull as the pencil is consumed.

Schedule of Mechanisms.

A schedule embracing the eight heads above enumerated, if supplemented by statements of the gauges and resistances of the wires used in the windings of the coils, affords a systematic and very convenient method of tabulating the facts concerning the construction of any arc lamp. An example of such schedule, filled up with the data of one arc lamp of recent pattern, is given at the end of this paper.

Electromagnets for Arc Lamps.

As the electromagnet plays so essential a part in the striking, feeding, and cut-out mechanisms of lamps, a short digression upon the particular forms of electromagnets appropriate to arc lamps is not out of place. The ordinary treatises on electricity have little to tell about the special properties of different forms of electromagnet; indeed, this all-important organ in modern electrical engineering has received very inadequate attention from writers on electricity. It is a familiar fact that the attraction of a horseshoe-shaped

magnet, whether of steel or iron, varies very greatly with the position of the iron armature, being great at small distances, but very rapidly falling away as the intervening space is increased. To devise a form of electromagnet whose attractive power shall be exerted over a fairly long range was at one time one of the practical problems of electricians, and it has been solved in various ways. The attraction which a solenoid, or tubular coil, exerts, when traversed by a current, upon an iron core introduced within its aperture, is not, in any position of the core, nearly as great as that exercised by an electromagnet of horseshoe type, constructed of equal amounts of metal, and energised by an equal current. On the other hand, the feebler pull of the solenoid upon its core is exerted through a very extended range. And by making the core of conical form, or by winding the coils of the solenoid in a conical fashion, it is possible still more completely to equalise the pull over a long range. Solenoids with cores are used in several well-known types of lamps in which a long travel is required. On the other hand, since the operation of striking the arc requires a short motion not exceeding one-twelfth of an inch, or two millimetres, in all those types of lamp in which a special electromagnet is used simply to strike the arc, a form of electromagnet is required which will exert a powerful pull over a short range. Further, for working certain clutch mechanisms and the like, it is desirable that a form of electromagnet should be found which, whilst having a travel of, say, one inch, should exert throughout the whole of that range a fairly strong pull, increasing of course toward the end. Experiments show that the special forms of electromagnet may be tabulated as follows:—

(*a*) *Short-range Magnets*.—1. Horseshoe form, if constructed with short thick cores, thick yoke and thick armature, giving compact magnetic circuit.

2. "Pot-magnet," straight core with external tubular envelope, connected by iron at bottom. Armature, a stout iron disk or lid.

(*b*) *Moderate-range Magnets*.—1. Horseshoe form with long thin cores and armature, giving a non-compact circuit.

2. Solenoid having a short fixed core extending part of the way down, and a second moveable core to be attracted in as plunger. The name "stopped solenoid" is suggested as appropriate for this form.

3. Two such as last, having a yoke connecting the two fixed cores, and a second yoke connecting moveable cores.

4. Stopped solenoid with plunger attached to an outer mantle [Kennedy's lamp, Fig. 10].

5. Electromagnet with conical poles protruding through hollow in armature [Thomson-Houston lamps, Figs. 14 and 25].

6. Electromagnets with oblique approach of armature. [Serrin's, Fig. 5; De Puydt's, Fig. 23; and many other lamps.]

(*c*) *Long-range Magnets*. — 1. Solenoid, cylindrical, with longer cylindrical core. Attraction greatest when entrant end of core just reaches the further side.

2. Solenoid, cylindrical, with long coned core entering with the point foremost.

3. Solenoid, conical, with long cylindrical core entering the thicker end of solenoid.

4. Special device for travel of unlimited length. A solenoid constructed in sections, which are switched into circuit progressively ahead of the core as the core travels down* [Thomas, 5788²; Lindemann, 163768⁷].

It must be borne in mind that the range of an electromagnet depends on the relative dispositions of the iron parts of the magnetic circuit and of the magnetising copper parts, and in no way upon the question whether the coil consists of a few turns of thick wire, or of many turns of thin wire.

Equalizers.

In sundry forms of lamp special mechanical devices have been introduced for the purpose of equalizing, throughout a given range of motion, the otherwise very unequal pull of the electromagnet upon its armature. Set-up springs with adjustable stops have been used for this purpose. A more satisfactory *equalizer (repartiteur)* is the device suggested by the famous conjuror, Robert Houdin, which is depicted in Fig. 1. Here the attraction of the electromagnet, E, for its armature *a*, is transmitted through a system of two curved levers, A and B, which rock on one another at a point of mutual contact which varies the "mechanical advantage" of the system, and partially or wholly, according to the curvature, compensates for the great increase of force as the distance of the armature diminishes.

The form of the equalizer of Foucault, as used in the Foucault-Duboscq lamp, is depicted in Fig. 2. Here the armature, *a*, which is stiffly pivotted eccentrically to allow of adjust-

* Figures in square brackets relate to patent specification or date.

ment, is attached to a lever, A, whose fulcrum is at F, and the opposing force of a spring, *s* (itself adjustable by the screw *r*) is applied through the curved rocking lever B. The vertical arm attached above F carries the detent D. Equalizers depending on use of a

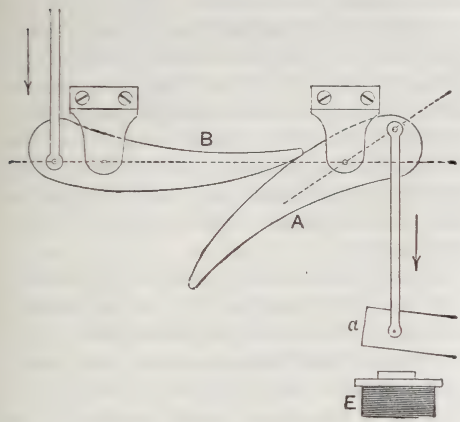


FIG. 1.—HOUDIN'S EQUALIZER.

rocking lever are to be found in several lamps. [Serrin's lamp; also Mackenzie, 95[82], and Common, 626[82]].

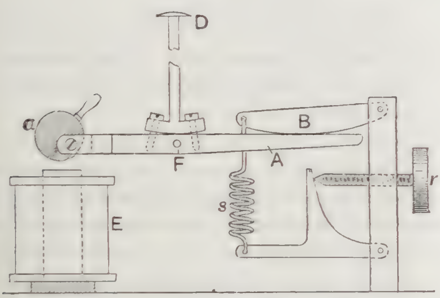


FIG. 2.—FOUCAULT'S EQUALIZER.

Returning from this digression, we have now to go separately over the eight items of the schedule, and point out how the various necessities have been met by the ingenuity of various inventors. As it is impossible to mention all instances of carrying out a principle, reference is made only to a few cases, preferably to the best known lamps.

[A.] DRIVING POWER.

The following devices have been used :—

1. *Gravity.*—Descent by its own weight of upper carbon holder [innumerable lamps]; ditto, aided by weights specially attached [Gülcher, 1915[82]]; ditto, partially opposed by coiled spring to compensate for consumption [Siemens, 366[88]]; clockwork driven by weights [Staite, 11783[47]]; lower carbon floated upward in mercury [Tommasi, 4405[79]].

2. *Coiled Spring.*—Drives by pinion and rack, or pulley and cord [Foucault, 1848 Staite, 11449[46]]. Differential action of two coiled springs [Foucault-Duboscq lamp].

3. *Electromagnetic Motor.*—(*a*) Suction of core by solenoid; (*b*) electric motor rotates and drives carbon rod [Bousfield, 523[79]; Breguet, &c.]; (*c*) electromagnetic vibrator drives carbon rod [Clark-Bowman, 1182[83]; Newton, 1623[83]; Pieper, 4133[86]; Holmes, 769[86].]

4. *Hot Air.*—Heated air rising from lamp drives fan to propel carbons. [Varley, 5656[81].]

[B.] STRIKING MECHANISM.

To strike the arc requires mechanical devices; but as these are to be actuated by the current itself, it is appropriate first to consider what electric mechanism is necessary or sufficient to actuate the movement. Assuming that the carbons are initially in contact when there is no current, the current when turned on must part them; the appropriate device is therefore an electromagnet (or solenoid with its core in lieu thereof) having its coils in the main circuit of the lamp. [Foucault, 1847; Staite, 11783[47], and in the vast majority of modern lamps.] If, however, the carbons are initially apart, the lamp must itself bring them together; and the appropriate device to actuate this movement will be an electromagnet (or solenoid) connected as a shunt, and therefore having fine wire coils of high resistance. Such an arrangement will bring the carbons together by the action of the by-pass current, and as this falls almost to zero on the contact of the carbons, they will be at once parted (and the arc struck) by the opposing force: this force may be that of gravity [Lontin, 1875] or a spring [Lever, 2092[82]; Thomson-Rice, Fig. 33]. The disadvantage of this second method is that the initial resistance of the whole series of lamps standing with their carbons parted is enormous unless there is a cut-out circuit. Another method of striking the arc is by cutting out a main-circuit electromagnet [Crompton, 346[82]; Bright, 377[82]].

The modes of parting the carbons are various :—

1. Drawing both carbons asunder by gearing [Foucault-Duboscq lamp].

2. Drawing down the lower carbon by electromagnet placed in base [Staite, 1178^{47}; Serrin, Breguet, Sellon, Newton, Pieper, Holmes, &c.], or by electromagnet situated at top [Crompton "E," 1881; Gramme; Silvertown Co.; Fein, 1888].

3. Lifting upper carbon rod [Roberts, 14198^{52}; Slater and Watson, 212^{52}; and the vast majority of modern lamps, Brush, Siemens, Crompton, Pilsen, Brockie-Pell, Thomson-Houston, &c.], or lifting upper carbon by an electromagnet situated in the carbon rod [Abdank, 1884]; or by lifting bodily the upper carbon and the whole of the feeding train [Crompton, 346^{82}; Fyfe and Main, 3821^{81}; Berjot, Wood, Hochhausen, Maxim, 1649^{80}; Gümpel, 253^{81}, &c.]; or by rocking the feeding train around a centre [Brockie, 2370^{82}; De Puydt, Fig. 23, p. 353].

The mechanical devices for performing these various actions are numerous, and their action is complicated by the endeavour of many

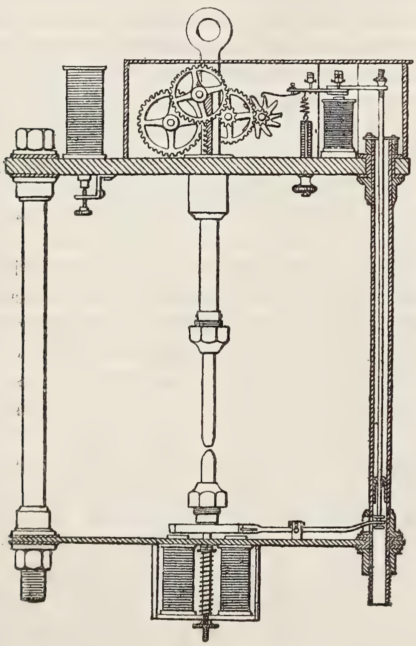


Fig. 3.—Breguet Lamp.

inventors to cause the same mechanism which initially strikes the arc also subserve the purpose of feeding the carbons. In some lamps, however, these functions are kept separate. An example of a lamp in which the striking and feeding mechanisms are kept separate is afforded by the Breguet lamp (Fig 3), in which an electromagnet draws down the lower carbon holder to strike the arc, whilst the feeding is accomplished in the subsequent gradual descent of the upper carbon. In the lamps of Newton, Sellon, and Holmes, there is used the special form of short-range electromagnet, *a* (2 in the list), having a central core and external tube of iron. There is a very numerous class of lamps in which a clutch is caused to grip the upper carbon holder, and then to raise it so as to strike the arc; the same clutch being subsequently so operated, as to permit the carbon holder—a smooth rod—to slide down by degrees as required, to feed the carbon pencil forward. Such devices are best considered under the heading of feeding mechanisms.

The adjustments of the striking mechanism may be of two kinds:—(1) adjustments of range, such as limiting stops and set screws; (2) adjustments of force, such as the regulable spring shown in Fig 1 at the bottom.

The main-circuit electromagnets, and solenoids, used for striking the arc, are wound with a wire of large enough section to carry the required current without undue heating, and are of small resistance. The weight of copper wire employed varies from one to four pounds; and the resistance varies from 0·05 to 0·2 ohms.

[C.] Feeding Mechanism.

The electric devices here differ in the case of lamps for parallel working and lamps for series working.

(*i.*) *For Lamps in Parallel.*—Assuming that the supply mains are kept at constant potential, then the lamp mechanism must be responsible for keeping the other factor of the electric power, namely, the current through the lamp, at a constant value. That is say, whenever by reason of the burning away of the carbon points the arc grows long, offering more resistance, and, therefore, reducing the current below its normal value, the lamp must automatically feed the pencils forward, and so re-adjust the current. It is obvious that, in this case, the weakening of the current through the lamp may be caused to bring the feeding mechanism into operation by the use of an electromagnet (or solenoid) in the main circuit. For if the armature of this electromagnet be held back by a spring or weight which only just counterbalances the pull of the magnet when the current is normal, the weakening the current will at once cause a movement of the armature which may be

utilised to relax a clutch, lift a detent, or release an escapement. And it is also obvious that in this case it is possible to arrange the same electromagnet which strikes the arc to actuate the feed. Examples of the use of a single main-circuit electromagnet to actuate both the striking and the feeding mechanisms are to be found in the Serrin lamp, in the Gülcher lamp, and in the Brush lamp as arranged for parallel working.

(*ii.*) *For Lamps in Series.*—Assuming that the dynamo is doing its duty, and keeping the current constant, then in this case the lamp mechanism must be responsible solely for keeping constant the potential between the terminals. Whenever by reason of the burning away of the carbons the arc lengthens and offers more resistance, if the same current is still supplied to it and forced through this greater resistance, it will burn more brightly, and the difference of potentials between the terminals of the lamp will rise above its normal value. The lamp must then automatically bring its carbons nearer, and re-adjust the potentials to the proper number of volts. It is obvious that the appropriate device to actuate the feeding mechanism must, in this case, be something that can play the part of a voltmeter; and will actuate the mechanism when the volts rise above their normal value. Practical voltmeters are of two kinds; (*i*) those which depend on the magnetic effects of the current that will flow through a wire of high resistance placed as a shunt across the two points between which the differences of potential exists, and (*ii*) those which depend on the heating effects of the current in such a wire. Either of these effects may be used to control the feeding mechanism of arc lamps; that is to say, the feed must be controlled by a shunt circuit, which will actuate the mechanism as soon as the potential rises above its normal value. The usual device is an electromagnet (or solenoid) of fine wire, and of high resistance (from 200 to 400 ohms), the armature of which is counterbalanced by the force of a spring, or by gravity, or by an opposing main circuit electromagnet (or solenoid). An alternative device, not, however, in general use, is a long thin platinum wire, which when heated by a current above the normal value will expand and actuate the feed. Thermal expansion has been attempted as a method of regulation by several inventors. [Lontin, 2074[77]; Siemens, 2281[78] and 2110[79]; Munro, 1626[82]; Edison, 2072[82]; Pollak, 1888, &c.]

In the following Table are comprised the several electrical arrangements for controlling the feeding mechanism:—

(*i.*) *Constant Potential Lamps* (*for Parallel Working*).

(*a.*) Series electromagnet, same as used for striking.
[Serrin; Gülcher; Brush; Crompton, &c.]

(*b.*) Series electromagnet, separate from the striking electromagnet.
[Fontaine.]

(*c.*) Differential arrangement. Series winding partly opposed in shunt winding, on separate cores or parts of mechanism.
[Lacassagne and Thiers, 2456[56]; Siemens; Brockie-Pell.]

(*d.*) Ditto, but wound on same cores.

(*ii.*) *Constant Current Lamps* (*for Series Working*).

(*a.*) Shunt electromagnet alone, acting against gravity or spring.
[Lontin, 1877; Lever.]

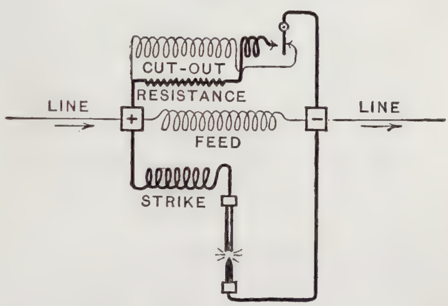
(*b.*) Shunt electromagnet separate from the striking (series) electromagnet.
[Numerous lamps. Breguet (Fig. 1); Crompton "E"; Sellon; Gramme; Pieper.]

(*c.*) Differential arrangement. Shunt winding pulling against series winding, on separate part of mechanism.
[Lacassagne and Thiers; Siemens "differential"; Pilsen; Crompton-Crabb "DD"; Thomson-Houston; Brockie-Pell; Kennedy.]

(*d.*) Differential Winding.
[Numerous lamps. Brush; Weston; "Simplex."]

The typical arrangement of circuits for lamps that are to be run on a system of arc lighting in series, is shown in a generalised diagram in Fig. 4. The striking coil is in the

FIG. 4.



main circuit; the feeding coil is a shunt, which if wound on the same core as the series coil in any of the differential systems must be so wound that the currents circulate in opposing senses. There is also added a cut-out circuit,

having both a shunt coil and a small series coil; but these must be so wound as to help one another's magnetic power, and the small series coil must itself be a shunt to the main circuit of the lamp.

We are now prepared to enter upon the mechanical devices which have been suggested for the feeding-mechanism of lamps. These are so varied, and run so curiously into one another, that no classification of them is entirely satisfactory. In a very large class of lamps there is a train of wheel work, usually driven by the weight of the descending carbon rods, the last member of the train being controlled through a detent or brake, by the electromagnet that is responsible for the feeding of the lamp. Most, but not all, of these lamps have a rack upon the upper carbon-rod to drive the train. But the rack lamps differ greatly amongst themselves. Again, there is another class of lamps in which the upper carbon-rod is smooth, but is assisted and controlled in its descent by a clutch or clamp, the clutch or clamp being in turn controlled by the feeding electromagnet. But there are also rack lamps in which a clutch or clamp is applied, not to the rod itself, but to a wheel driven by the descending rack. There are, however, certain main features of classification about which there need be no ambiguity.

Feed Motions.

[*i.*] *Rack and Train* controlled by—

- (*a.*) Star wheel and detent [Staite, 18783^{47}; Foucault-Duboscq; Serrin, 653^{58};
- (*b.*) Fly and detent [Staite, 1848; Duboscq, 1855].
- (*c.*) Brake-wheel and brake [Chapman, 739^{55}; Crompton, 346^{82}].
- (*d.*) Escapement with pendulum or balance and detent [Siemens, 4949^{78}; Harding, 3166^{81}; Waterhouse, 5185^{81}].
- (*e.*) Escapement and paddle [Waterhouse, 5185^{81}].
- (*f.*) Governor with detent or moderator [Waterhouse, 5185^{81}].
- (*g.*) Magnetic brake-wheel or detent [Brockie, 1713^{82}; Harling, 3473^{81}].
- (*h.*) Liquid brake [Hopkinson, 153^{81}].

[*ii.*] *Clutch or Clamp on Rod.*—

- (*a.*) Tilting ring, tilting eyelet, &c. [Slater and Watson, 212^{52}; Brush, 2003^{78}; Lumley, 1249^{82}; Lever, 2092^{82}; Thomson-Houston; Waterhouse, &c.].
- (*b.*) Split cone gripped by fork [Slater and Watson, 212^{52}].
- (*c*) Split nozzle forced into cone mouthpiece [Bürgin, 4820^{81}].
- (*d.*) Split tube held together by oblique levers [Rogers, 3236^{82}].
- (*e.*) Gripping springs at side [Lever, 3599^{81}; Munro, 1626^{82}].
- (*f.*) Gripping fingers [Roberts, 1419^{52}; Joel, 5157^{79}; "devil's claws," Harding, 3166^{81}].
- (*g.*) Washer jambed by ball bearing [Young, 1689^{82}; or roller, Newton, 4559^{81}].
- (*h.*) Tilting clamp or nipping clamp [Common, 626^{82}].
- (*j.*) Nipping lever [Grimstone, 1670^{81}; Mondos, 5490^{81}].
- (*k.*) Scissors lever [Joel, 3970^{84}; Jarman, 563^{82}; Gerard-Lescuyer, 2992^{82}].
- (*l.*) Spiral spring surrounding rod [Keilhotz, 1886; Thouvenot, 1887].
- (*m.*) Forward-pointing springs (lobster-trap) [Newton, 1623^{83}; Clark-Bowman, 1182^{83}; Holmes, 769^{86}; Hawkes, 157^{82}].

[*iii.*] *Clutch-wheel or Brake-wheel*—

- (*a.*) Nipping lever outside brake-wheel [Gramme, 1861; Common and Joel, 1040^{81}; Brockie, 4419^{82}].
- (*b.*) Nipping lever inside rim of wheel [Union Co., 392^{82}; Brockie, 4419^{82}].
- (*c.*) Elastic band brake [Statter, 2985^{85}].
- (*d.*) Elastic internal ring brake [Siemens, 6987^{87}; Fein, 1888].
- (*e.*) Wheel lifted against brake or detent [Bürgin, 4820^{81}].
- (*f*) Brake-wheel lifted upon brake-lever. [Gümpel, 253^{81}; Crompton-Crabb, 2539^{83}].
- (*g.*) Friction-pad on rim of wheel [Abdank, 1882].

[*iv.*] *Screw Motion*—

- (*a.*) Screw worked by weight of upper rod [Hopkinson and Muirhead, 153^{81}; Cance, 3976^{81}; Akester, 2419^{82}].
- (*b.*) Screw worked by motor [Tchikoleff, 1874].
- (*c.*) Screw worked by step-feed [Street-Maquaire, 9666^{85}].
- (*d.*) Screw worked by vibrated wheel [Siemens, 6987^{87}].

[*v.*] *Cord and Pulley Motions*—

- (*a.*) Cord and pulley to core of solenoid [Archereau, 1848; Jaspar, 83^{79}].
- (*b.*) Cord and pulley connecting carbons, with long-travel solenoid [Pilsen lamp, 1397^{80}; Doubrava, 1033^{86}].
- (*c.*) Cord gripped by controlling cam [Harding, 4590^{79}].
- (*d.*) Cord and pulley for differential feed [Weston, 1883; Kennedy, 1888].

[*vi.*] *Step-by-Step Motions*—

- (*a.*) Step detent worked by electromagnet [Deleuil, 1856; Brockie, 898^{82}; Gate-

house and Kempe, 2569[82]; Kennedy, 5524[81]].

[vii.] *Magnetic Clamps and Clutches*—

(*a.*) Tilting magnet clutch on rod [Roberts, 14198[52]; Gülcher, 2038[81]].

(*b.*) Magnetic clamp on brake-wheel [Harling and Hartmann, 3473[81]; Hardt, 1886].

[viii.] *Electric Motor Action*—

(*a.*) Motor screws carbon up or down [Tchikoleff, 1874, and 2198[81]; Maquaire, 1889.]

(*b.*) Winds up with cord or rack [Andrews, 2321[79]; André, 2764[80]; Bousfield, 5237[9]; Breguet, 1879].

(*c.*) Motor itself controlled by shunt magnet [Thomson-Houston, 315[80]].

(*d.*) Motor with copper damper [Thury, 1888].

[ix.] *Hydrostatic and Pneumatic Action*—

(*a.*) Carbons controlled by admission of liquid or gas [Lacassagne and Thiers, 2456[56]; Hopkinson, 3509[80]; Leibold, 1886; Sedlaczck, 1883].

[x.] *Vibrating Feeds*—

(*a.*) Make-and-break lever vibrate forward-pointing springs [Newton, 1623[83]; Pieper, 4647[85]; Holmes, 7698[6]].

(*b.*) Make-and-break lever actuates escapement [Harding, 3166[81]].

(*c.*) Make-and-break lever actuates detent on train [Gramme, 1880].

(*d.*) Make-and-break lever hammers rod through clutch [Letang, 5509[87]].

(*e.*) Make-and-break lever works internal clutch-wheel feed [Fein, 1888].

(*f.*) Make-and-break lever drives pallet and screw feed [Siemens (Alteneck), 1885.]

[xi.] *Periodic Feeds*—

(*a.*) Perodic drop of upper carbon and lift through definite range [Brockie, 898[82] and 1713[82]].

(*b.*) Periodic currents to magnet sent through second wire [André, 4948[81]].

[xii.] *Continuous Feeds*—

(*a.*) Clockwork step feed, length of stroke varied by magnet [Brockie, 898[82]].

(*b.*) Pendulum or governor, having rate varied by magnet [Waterhouse, 5185[81]].

(*c.*) Rack-train controlled by magnetic retardation on copper wheel [Niaudet, 1878].

[xiii.] *Hammering Feeds.*—

(*a.*) Rod driven through clutch by vibrating hammer [Letang, 5509[87]; Capito and Hardt, 1887].

(*b.*) Ditto, by tilting lever [Jolin, 2570[83]].

(*c.*) Ditto, by magnetic pile-driver on rod [King, 1888].

Outside the classification adopted above are several well-marked features of mechanism; one of these is the *parallelogram motion*. A typical case of this is afforded by the well-known Serrin [653[59]] lamp (Fig 5). A jointed

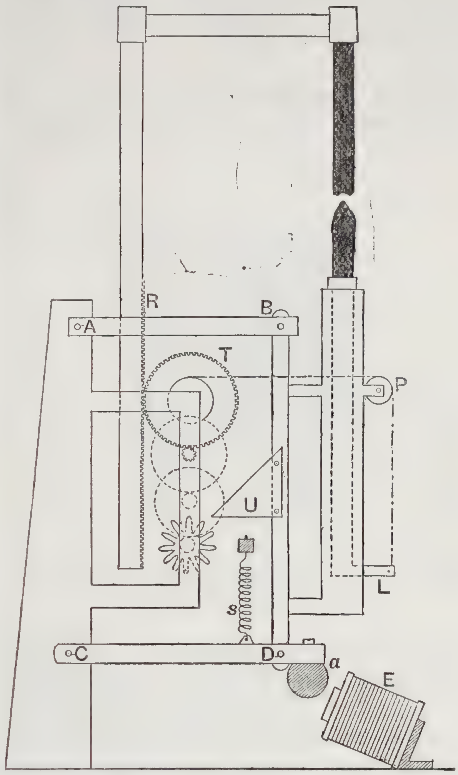


FIG. 5.—SERRIN'S LAMP.

parallelogram is constituted by the pieces which meet at A B C D. The side, A C, is fixed, being part of the frame, whilst the levers, A B C D, rise and fall through a small angle, carrying with them the upright, B D. To this upright is fastened a sleeve, through which the lower carbon-holder passes. This moving parallelogram is held up by a spring, *s*. When the electromagnet, E (in main circuit), attracts its armature, *a*, the parallelogram, and with it the lower carbon, sinks, and so the arc is struck. At the same instant a projecting triangular detent, U, engages against the star wheel of the driven train and locks it, so that the upper carbon cannot descend. As the carbons are consumed the current is weakened, owing to the increasing resistance of the lengthening arc, and the electromagnet lessens its attraction; consequently the parallelogram gradually rises, until a moment occurs when the detent ceases to lock the star-wheel. The upper carbon-

holder is now free to descend a little, driving the train of wheels, shortening the arc, restoring the normal current, and so again causing the electromagnet to pull down the parallelogram and lock the wheels. Parallelogram motions are to be found also in Bürgin's lamp [4820[81]], and in Siemens' pendulum lamp [4949[78]].

Another characteristic mechanism is the *see-saw* lever. Fig. 6 shows the form used in

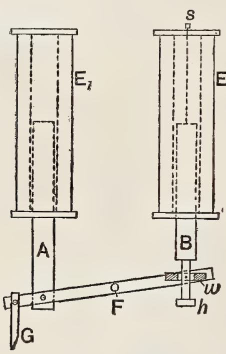


FIG. 6.—SEE-SAW OF BROCKIE-PELL LAMP.

the Brockie-Pell lamp [1268[85]]. The earliest use of the see-saw, attracted at opposite ends by series and shunt magnets respectively, occurs in the lamp of Lacassagne and Thiers [2456[56]]; whilst modern examples are Weston's lamp, the Thomson-Houston lamp (Fig. 14), and Fein's lamp of 1883. [Also Moffat and Chichester, 3441[81]; and Chadburn, 2755[81] where the see-saw works a clutch]. A compact modification of the see-saw mechanism occurs in one form of Weston's lamp, and again in Kennedy's lamp of 1888, Fig. 10. Here the lever is replaced by a pulley over which passes a cord or ribbon of metal. In this lamp the shunt solenoid is furnished with a plunger core, whilst the series solenoid on the left has a plunger and an external iron mantle to increase its power. The smaller pulley communicates the motion to a clutch. The advantage of the see-saw, and of its pulley equivalent, is that such an arrangement enables the lamp to be used as either a constant potential lamp or as a constant current lamp. In the former case the shunt coil holds up its end, whilst the see-saw is operated by the variations of the current in the series coil. In the latter case the actions are the inverse of this.

The *rack-train* mechanism which forms the first-class in the preceding list, presents two special points. As this mechanism is in itself non-retractile, and can only propel the carbons forward, it cannot be used with non-homogenous carbons of second quality, unless special provision is made in the striking mechanism of the lamp for a retractile movement. There is nothing retractile, for example, about the Breguet lamp (Fig. 3), but there is about the Serrin (Fig. 5), for the lower carbon-holder (which descends to strike the arc) is never held tight down by the electromagnet, but takes up a position of equilibrium. The other point is that in these rack-train lamps some device is requisite to lock the train at the instant of striking, otherwise the feed motion would neutralise the strike-motion. In some lamps [Breguet, Sellon, &c.] there is a mechanical connexion from the striking part to lock the feed. In some other lamps the action is performed electrically. In the De Puyt lamp (Fig. 24), a pin on the train frame engages with a forked connecting-piece from the feeding-lever.

A characteristic arrangement, applicable to rack-train lamps, is that in which, for the purpose of striking the arc, the whole train mounted in its framework, together with the rack and the upper carbon-rod, is bodily lifted by the use of an electromagnet in the main circuit. [Crompton, 3468[82]; Fyfe and Main, Hochhausen, Gümpel, Berjot, Wood, Maxim, &c.] More neat is the method of rocking the train bodily around the axis of one of the wheels of the train. [Brockie, 2370[82]; and De Puydt, Fig. 23.]

Passing from the *rack-train* lamps to the *clutch* lamps, it may be noted how much ingenuity has been expended in attempting to find a form of clutch which will prove reliable under all conditions of working. Two of the very earliest forms of clutch mechanism are worth recalling in this connection. These are both due to Slater and Watson [2125[2]]. The first (Fig. 7) shows a carbon rod sliding through a couple of rings or eyelets, which are tilted by the attraction of an electromagnet to grip and raise the rod. In the second (Fig. 8) the clutch consists of a split conical washer, the two halves of which are hinged together. These are compressed by the rising of a fork, which nips and raises them. The tilting ring introduced by Brush is too well known to need comment. Lever's modification of the tilting ring is shown in Fig. 9, the rim below the ring causing the thrust to act more obliquely at first, and

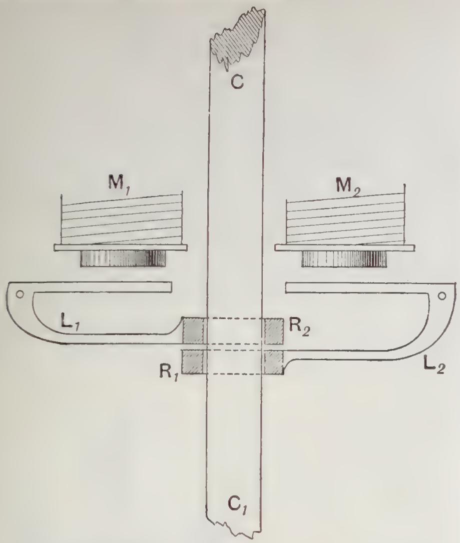


FIG. 7.—SLATER AND WATSON'S CLUTCH.

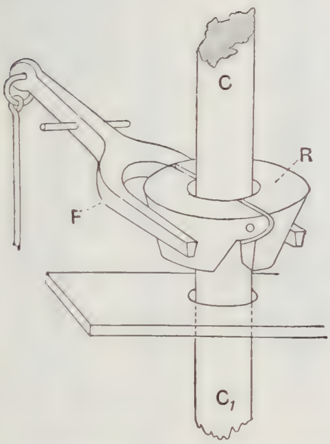


FIG. 8.—SLATER AND WATSON'S SPLIT CONE.

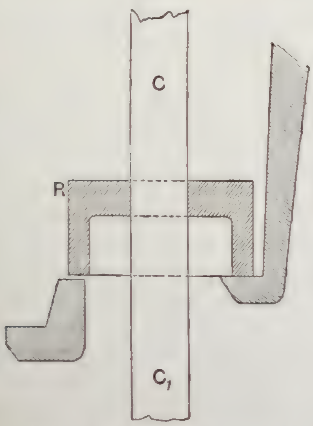


FIG. 9.—LEVER'S CLUTCH.

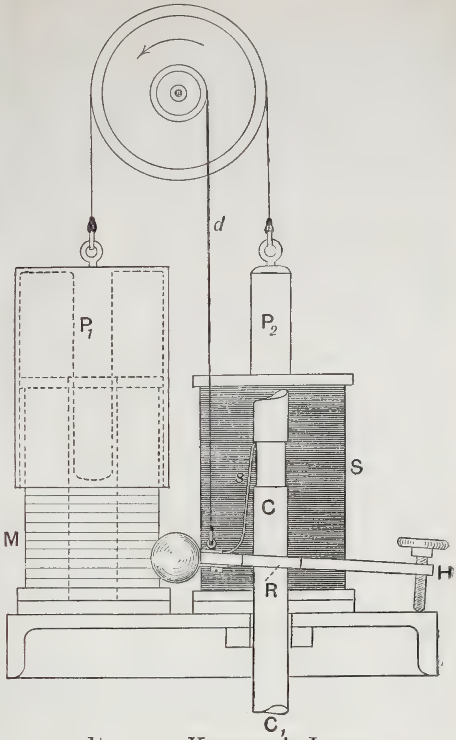


FIG. 10.—KENNEDY'S LAMP.

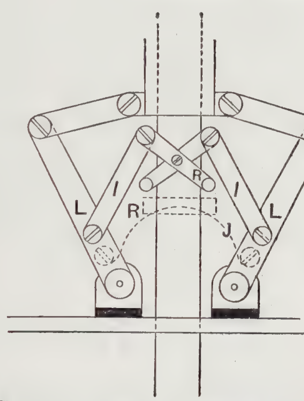


FIG. 11.—JOEL'S SCISSORS JOINT.

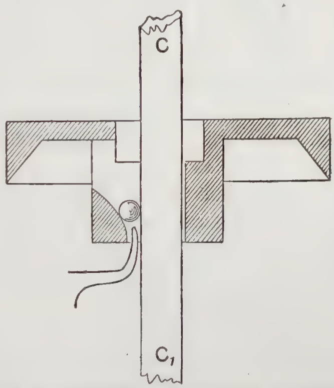


FIG. 12.—NEWTON'S ROLLER CLUTCH.

allowing the clutch to work even when the aperture is considerably worn. In the latest forms of this clutch, the ring has a tail-piece which is hinged to the frame of the lamp. Another successful form of tilting clutch is shown in Fig. 10 (p. 345), which represents the mechanism of Kennedy's lamp. The clutch has a long tail, provided with an adjusting screw to regulate its position, and bears against the carbon-rod by a slender spring, *s*, above. It is worked by a thin cord, *d*, running over a pulley in connection with the differential arrangement of shunt, S, and series, M, solenoids described above. A clutch provided with a spring that bears against the carbon-rod is also found in the Clark-Bowman lamp [1182^{83}], the feeding in this case being accomplished whilst the clutch is held up, by giving to it a mechanical vibration. In the Kennedy lamp the spring on the clutch also serves the purpose of finally arresting the descent of the carbon-holder, catching on a groove cut around its upper end when the carbon pencil is all consumed. Another simple clutch with spring mounting, worked by the mutual repulsion between two similarly magnetised cores, has been devised by Swinburne [11893^{86}]. Clutches of the knee-lever type have been devised by Lorrain [183^{83}] and Joel [3970^{84}]. The more complex "scissors-joint" levers, used in one of Joel's lamps, are drawn in Fig. 11 (p. 345). Their action is obvious, as their upper end is raised by the upward pull of the electromagnet or solenoid they grip, and raise the carbon-rod, and they relax their grip on being lowered to feed the arc. Very similar devices are found in Gerard's and Jarman's lamps. An ingenious species of clutch, by F. M. Newton [4559^{81}], is illustrated in Fig. 12 (p. 345). This consists of a ball-bearing or roller-bearing, which on the raising of the collar in which it lies jams against the carbon-rod and raises it. Another extremely simple clutch [Lorrain, 639^{83}], consists of a plunger working horizontally through a solenoid, pressed sideways by a spiral spring against the carbon-rod; the pressure of this is taken off, when feeding is required, by the pull due to the current in the solenoid, which is connected as a shunt. Rogers' [3236^{82}] simple and very efficient form of clutch consists of a split-tube, the parts of which are connected together by a pair of oblique links, making a sort of parallel motion. This form is shown in Fig. 13.

In the Thomson-Houston lamps so widely used in the United States, a peculiar clutch is employed, consisting of a pair of levers jointed together, one of them being perforated with an eyelet through which the carbon rod passes. The mechanism of this lamp, shown in Fig. 14, consists of a see-saw lever, L L, pivotted at O, and provided with a long tail, T, the motion of which is moderated by an air dash-pot. Below is an electromagnet, M, in the main circuit, and above is a second, S, which is connected as a shunt. The pole-pieces of both are of of conoidal shape, protruding through apertures in the armatures, *a a*, and *b b*, to give longer range of pull. The lower and upper arms of the clutch, marked R and K, close

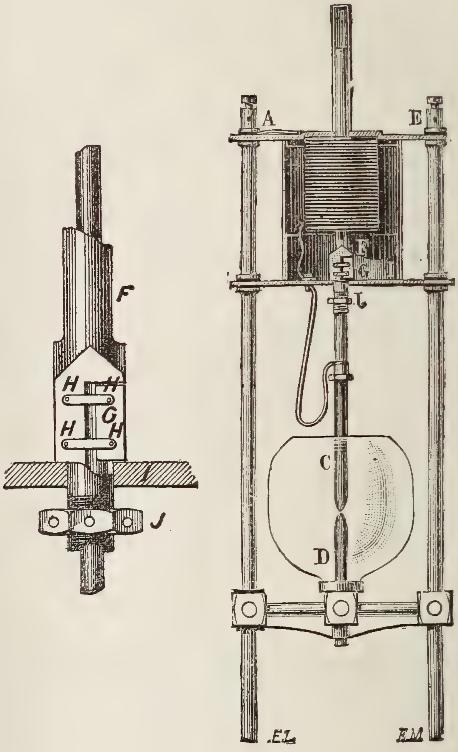


Fig. 13.—Rogers' Clutch.

together when the tail, T, rises, gripping the carbon rod, C, and raising it. From this diagram, which also shows the electric connections, it appears that the current entering the lamp through an insulated terminal at + P, flows first round M, and then goes to the frame of the lamp Thence it divides, the main current finding its way to the upper carbon-holder, and so through the arc to the lower carbon, whence it returns (by a route not shown) to the insulated negative terminal, −P. A smaller portion of the current flows up round the shunt electromagnet to −P. The arc

is struck by the preponderating main-circuit current in M attracting the lever end of the see-saw lever, and raising the clutch. The feeding is accomplished by the preponderating pull of the shunt magnet as the arc increases in length. The resistance wire across from + P to *c* constitutes a cut-out circuit, which is brought into operation by the augmented current in S on any failure of the main current. The small coil connected across from + P to the lamp frame is a mere adjustment to regulate once for all the power of the series coil, *m*, relatively to that of the shunt coil, S.

It will be noted that in the operation of all these clutch actions there are really four periods. In striking the arc there is a first

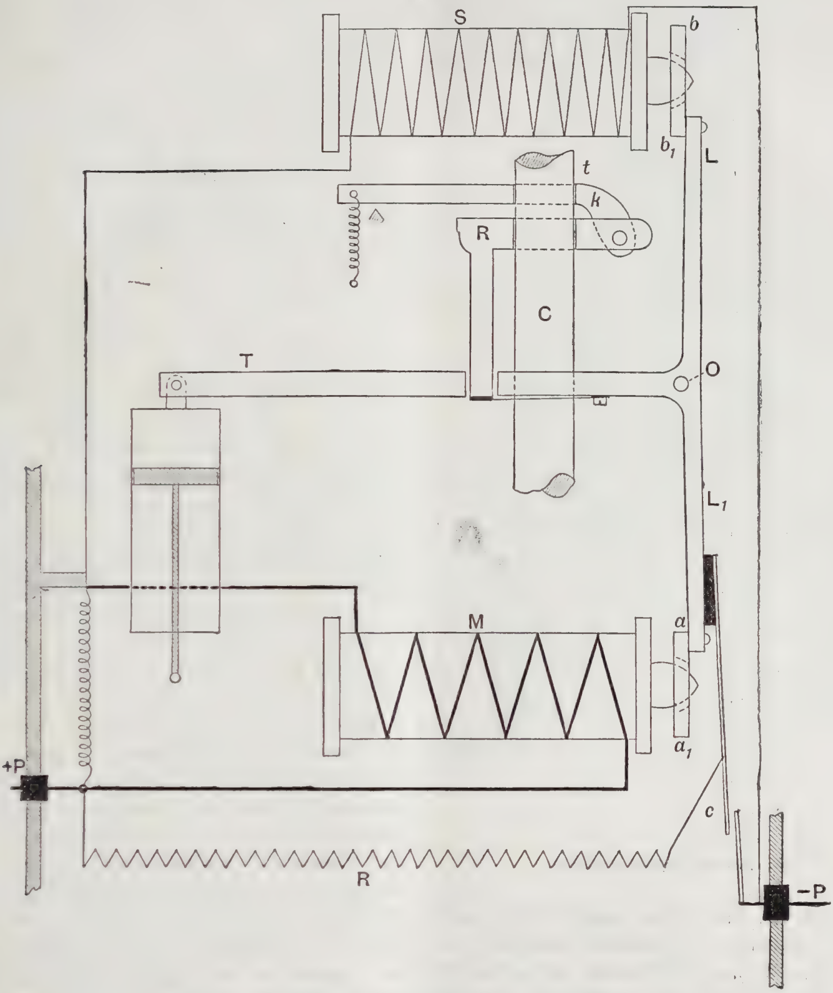


FIG. 14.—MECHANISM OF THOMSON-HOUSTON LAMP.

stage of affairs, where the clutch rises sufficiently to grip the carbon rod, immediately followed by a second stage, during which it rises still further, and lifts the carbon rod, so striking the arc. During the third stage or period the clutch still retains its grip, but as the arc burns away the clutch is gradually lowered. This is due, in constant potential lamps, to the weakening of the main current; in constant-current lamps, to the increasing opposing action of the shunt. The fourth stage is reached when the arc has burned away so far that the clutch has been lowered to the point where it begins to relax its grip, and now feeding commences, the rod slipping a little, but the clutch simul-

taneously rises a little, and grips again, again to descend. In a well-adjusted clutch lamp the clutch is indeed incessantly rising and falling through minute distances about the critical position. A bad clutch, or one that is deranged by dirt, will overfeed, and then rise too far, feeding spasmodically. Theoretically, all these clutches possess the retractile property so useful in keeping a steady arc when the carbons are of indifferent quality. But it is obvious that their perfection of action is impaired by dirt, dust, and inequalities in the surface of the carbon-rod due to wear and tear.

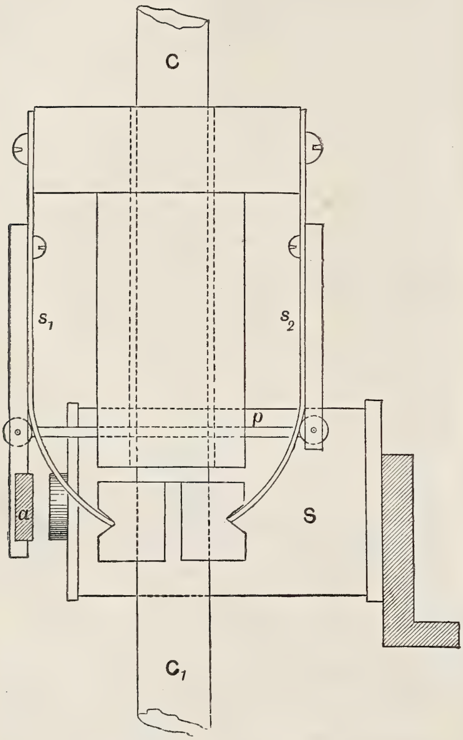


FIG. 15.—HOLMES'S FEED.

Clutches of the class termed "forward-feeding" belong to a different category, as they have, for the most part, no retractile power. In Newton's form [16238[83]] a piece of steel curry-comb, bent so as to form a sort of lobster-trap, encircles the carbon-rod, and forces it gradually forward when mechanical vibrations are imparted to it by a lever, working with a vibration on the plan of the well-known electric-bell vibrator, from the armature of a shunt-magnet. The latest variety of this species of forward feed is that of Holmes [7698[86]], shown in Fig. 15. Here, a shunt electromagnet, S, attracts an armature, *a*; the latter being mounted upon a vertical lever. The carbon rod, C C_1, is gripped between two blocks which are pressed against its sides by two curved springs, s_1 and s_2. The armature lever is attached to s_1, and is connected across by a small rod, *p*, to the spring s_2. When the armature, *a*, is alternately vibrated backward and forward by the magnet, the gripping blocks propel the carbon downwards. The make-and-break device which turns the current off and on in the magnet coils, is not shown in the cut. It consists of an ingenious modification of Holmes's snap-switch.

Passing to the *clutch-wheel* or *brake-wheel* type of lamps, we may remark that although so far back as 1861 Gramme attempted to construct on this plan a lamp (the existence of which was only published to the world in 1888 by M. Fontaine), this species of mechanism appears to be essentially British. The device of applying a clutch to a wheel in order to feed that wheel forward by degrees, the reciprocating motion of the clutch lever being converted into a motion of rotation of the wheel, is already familiar to engineers in the so-called "silent feed" movements used in spinning and weaving machinery. A clutch applied to the periphery of a wheel first grips the wheel, then turns it a little. In weaving machinery the "feed" acts in the direction in which the clutch propels the wheel, but in its application to the arc lamp the action is reversed, for the weight of the carbon-rod propels the wheel in a direction opposed to the grip of the clutch, and the feeding takes place at those instants when the clutch releases its grip. The matter is best studied by reference to actual cases. Fig. 16 depicts the clutch-wheel of Common and Joel. The descending rack, R, drives the wheel, D, by means of the pivot, P. Pivotted loosely around the same arbor is a heavy lever, which is prevented by a stop, S, from descending too far. Pivotted to this lever at L is a second lever, with an enlarged end to grip against the surface of the wheel. The tail of this nipping lever is attached by a pin to the iron core of a solenoid, M. (The latter is wound with a main-circuit coil only if wanted for use in parallel, or with a main coil and an opposing shunt coil if for use in series.) When the current in the solenoid draws up the core, the nipping lever first turns around L and grips the wheel; any further rise of the core will cause the two levers and the wheel to turn bodily together round the arbor, and this second action causes the arc to be struck. Then begins the

third period of action, during which the levers slowly descend until the weight-lever touches S. Then the fourth period begins; any further descent of the core causing the nipping lever

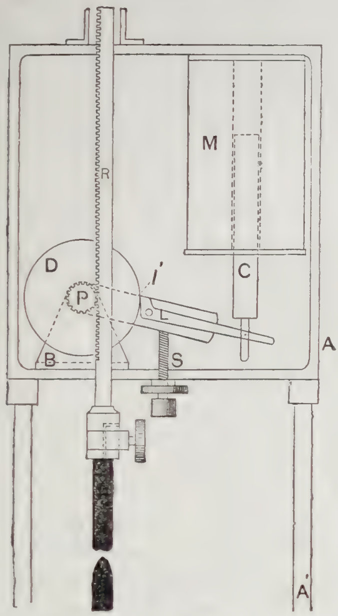


FIG. 16.—COMMON AND JOEL'S CLUTCH-WHEEL.

to release its grip, and allowing feeding to take place, followed by a slight rise in the core and renewal of grip.

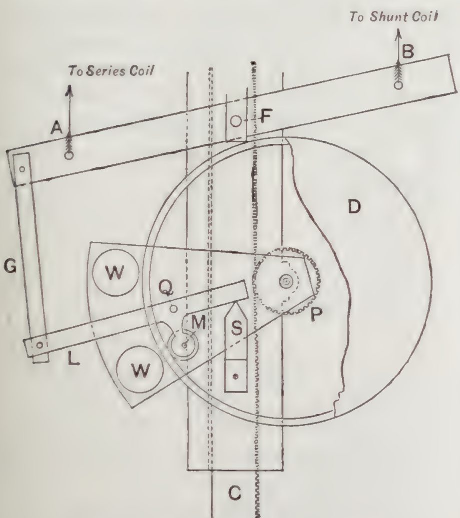


FIG. 17.—BROCKIE-PELL LAMP.

A form of clutch-wheel lamp which has become deservedly popular of late is that known as the Brockie-Pell [4419[82] and 12681[85]].

The see-saw belonging to this lamp was shown in Fig. 6 (p. 344). The descending carbon-rod drives a wheel having a strong projecting rim, at the inner surface of which a brake is

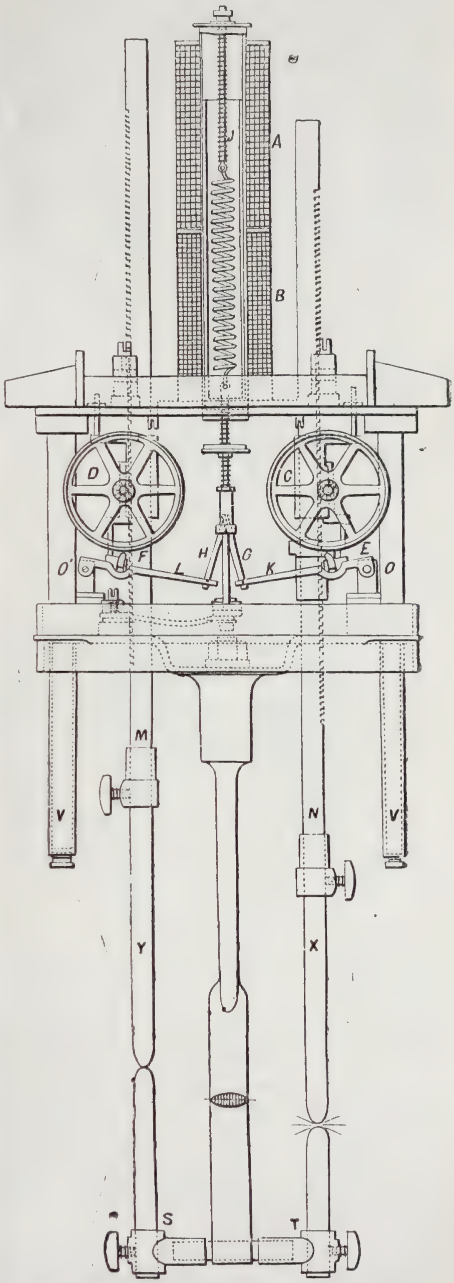
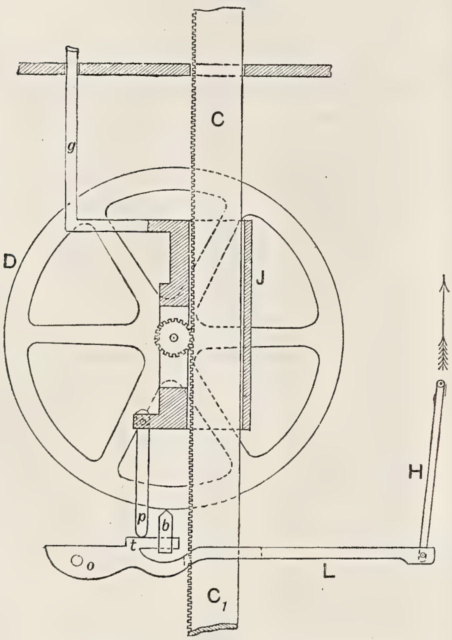


FIG. 18.—CROMPTON-CRABB D D LAMP.

applied. This consists of a small leather pad, m, fastened to a short arm which projects downwards from the nipping lever, L, pivotted

at Q to a sector-shaped lever behind, which carries two weights, W W, to increase its downward-bearing power. This weight-lever is loosely pivotted on the arbor, P, and turns solidly with the wheel when the brake is applied. There is a stop, S, to limit the descent, but it is in this case applied to the tail of the nipping lever. A connecting link, E, joins the nipping lever, L, to the see-saw. The internal position of the brake appears to have two advantages, namely, longer leverage around the fixed pin, making the feed more sensitive, and greater protection from dust and dirt. One peculiarity of the Brockie-Pell lamp is seen by reference to Fig. 6 (p. 344), namely,

FIG. 19.



BRAKE-WHEEL OF CROMPTON-CRABB LAMP.

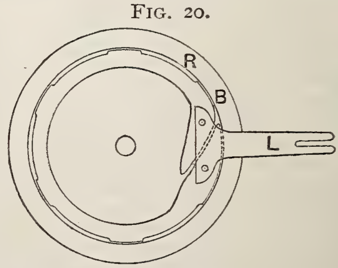
the device by which the core, B, of the shunt coil is allowed a certain travel upwards before it pulls at the see-saw lever, its thinner part passing freely through a swivelled washer, *w*, on the see-saw. But the washer is of iron, and the core has an enlarged head, *h*. These adhere by magnetic attraction when the shunt coil comes into operation.

Another very successful form of lamp is the Crompton-Crabb "double differential" [2539^{83}], shown as a whole in Fig. 18 (p. 349), and in detail in Fig. 19. In the lamp shown in Fig. 18 there are two carbon rods, M and N, of which N comes first into operation, afterwards changing over. On each carbon-rod is cut a rack which drives a brake-wheel, or, rather, a pair of brake-wheels, one behind the other on the same pinion. The arbor bearing is not, as in the two preceding lamps, fixed in the frame of the lamp, but passes through a short sleeve or jockey, which, when the wheel is free to turn, can slide up or down on the carbon-rod, but is prevented from turning sideways by a guide pin, *g*, above. Below the brake-wheels stands a lever, L, pivotted at *o*, and attached by a link, H, to the core of the solenoid overhead. This lever carries a small table, *t*, and a brake-piece, *b*, faced with phosphor-bronze. When the lamp is out of action, the free end of the lever is down, and the weight of the wheels and the carbon holder bears down upon the table, *t*, through a pin, *p*, which projects down from the jockey-sleeve. In this position the wheels do not touch the brake-piece, *b*, and are free. When the current is turned on, the main coil of the solenoid attracts its core, first drawing up the lever, which, turning on its pivot as it rises, brings the brake-piece against the rim of the brake-wheels and clamps it. Secondly, the wheels being thus prevented from turning, any further rise of the lever lifts the brake-wheel, jockey, and carbon-holder bodily (the weight of them all resting on the brake-piece), thus striking the arc. Thirdly, as the arc burns away, the lever again descends, until, fourthly, when the tail-piece rests on the table and takes the weight off the brake, the feeding begins. There are many other points of interest about this lamp which cannot here be discussed.

Other forms of brake-wheel have been used with success, notably an elastic band-brake, resembling Appold's well-known device, applied outside a smooth wheel, in Statter's lamp [2985^{85}].

The most recent form of clutch-wheel is

FIG. 20.



SIEMENS'S CLUTCH-WHEEL.

that devised by Alexander Siemens, 6987^{87}, illustrated in Fig. 20. The lamp to which this device is applied is a holophote lamp for search-lights, with a screw-feed, the screw

being turned by this clutch-wheel. It is about one inch in external diameter, and has a projecting rim, R, within which lies an internal metal ring, B, slightly sprung outwards, and cut obliquely, somewhat in the manner of the elastic metal packing-rings used in engine pistons. The two ends of this internal split ring are joined, by two pins, to a small lever, L, which projects outwards. When a reciprocating motion, of either large or small range, is imparted to the forked end of this lever, this internal clutch alternately bites against the rim and pushes it forward, and then releases its grip and draws back. This device, which appears to be a really new mechanism, constitutes a true positive feed.

The same device re-appears in a recent lamp by Fein [1888] which has a main circuit-magnet striking the arc by drawing down the lower carbon, and a shunt-magnet for feeding, which vibrates an armature by make-and-break arrangement. The upper carbon-holder is smooth, of rectangular section, with a smooth feeding-roller firmly pressed by a spring against it. This feeding-roller is attached to a clutch-wheel like Fig. 20 (p. 350). The lamp will work even upside down. Unlike the clutch-wheel devices previously described, Fein's feed is non-retractile. The latest patterns of clutch-wheel feeds are those of Mackie [7184⁸⁷] and Mathis [10740⁸⁷]. The advantages of the clutch-wheel mechanisms over the clutches that act directly on the rods, may be summed up by the remark that they render the operation of the lamp independent of dust and dirt.

Of lamps with *screw-feed* motions the most recent are the projector lamp of Siemens [6987⁸⁷] mentioned above, and a motor lamp by Maquaire, which is now being used at the Kensington-court lighting station. In the latter an ingenious and simple method of reversing the motion of the motor armature is adopted, so that both striking and feeding are accomplished by the same screw. This lamp is further described below.

The class of lamps in which cord and pulley mechanism is employed in conjunction with a long range open solenoid, goes back to the early examples of Archerau and Jaspar. In the more complex Pilsen lamp [Krizik and Piette, 13978⁰] two solenoids are used, each with its own coned core, the plungers being connected by cord and pulley, and each bearing one carbon pencil. The arrangement of the circuits of the recent form of lamp is shown in Fig. 21, the core, A, being drawn into the main-circuit solenoid, C, to strike the arc, whilst the differentially-wound solenoid, P, varies its pull on the core, B, according as the carbons are required to approach, to stand still, or to recede, the former action occurring

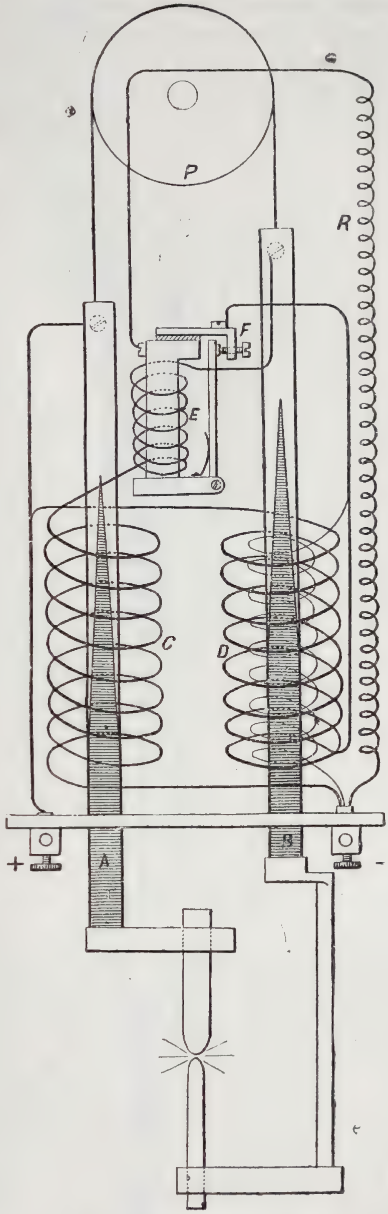


FIG. 21.—PILSEN LAMP.

when the shunt current prevails. The special cut-out mechanism, E F, will be alluded to later.

A much simpler pattern of lamp has been several times described with various modifications in detail by Jaspar, 1878; Romanze

[3901^{84}], Andrews [3393^{82}], and lastly by Menges, 1887, whose form is shown in Fig. 22. Here the long core, S N, is drawn up into the solenoid, wound differentially with a coarse wire, A, and a fine wire winding, B. A heavy piston of metal on the top of the upper carbon-holder, *d*, serves both to counterpoise the weight of the core, and to check, as it slides in the surrounding tubes, any too sudden movements. It is often claimed for solenoid

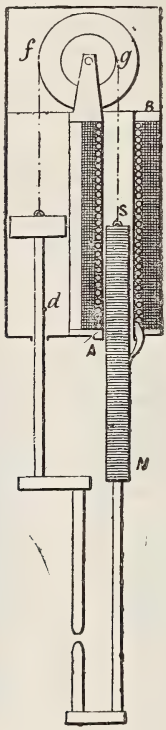


FIG. 22.—MENGES.

lamps that the absence from them of all mechanism renders them superior to all other species of lamps. Yet they are not free from defects; they do not always burn steadily; some of them have the evil habit of "pumping;" and so simple a matter as the elongation of the cord which connects the plungers may put their regulating properties to confusion. In a recent modification by Doubrava the iron cores are fixed, and the solenoid coils slide up and down over them, giving motion to the carbons.

The *screw-feed* lamps have been already touched on. Of these, the most successful in practice is the Cance lamp [3976^{81}], which operates by the weight of the upper carbon. The screw is prevented from turning by a nut gripped until feeding is necessary. In Siemens' holophote lamp [6987^{87}], and in Maquaire's new lamp [1889], the mechanical turning of the screw forces the carbons forward.

Amongst *magnetic-clutch* lamps the Gülcher lamp, as improved by the Gülcher Company [Whiteman, 1915^{82}], still holds its own. In this lamp the single counterpoised horseshoe electromagnet—with unequal limbs—sticks itself on by one pole to the iron carbon-rod, and by the other pole attracts itself upward to strike the arc. For constant potential work it is a very steady lamp. More recently, magnetic clutch-wheels have been used by Dittmar [1886], and by Trott and Fenton [6910^{84}].

Motor lamps have been devised from time to time, those of Tchikoleff, Schuckert, and Gray being perhaps the best until recently. The latest lamp of this type is that of Maquaire [1889]. In this lamp there is a Pacinotti ring upon a vertical pivot, on which a worm is cut. This gears into a large wheel, the pinion of which drives the upper carbon-holder by a rack. The motor ring stands between the pole-pieces of a powerful electromagnet. By rotating it in one direction it strikes the arc; by rotating it in the reverse direction it feeds the arc. The direction of its rotation is reversed by reversing the direction of the current in it. This is accomplished in the following ingenious way. The coils of the electromagnet are in the main circuit; and from a point midway along these coils a branch wire goes to one of the brushes of the armature. The other brush is connected to the tongue of a sort of relay, and stands between two contacts, one of which goes to one end, the other to the other end of the coils on the electromagnet. By raising or lowering the tongue the armature is thus connected as a shunt, either to one-half of the magnet coils or to the other, the current in it being in opposite directions in the two cases. The tongue of the relay is controlled by a separate shunt coil, which attracts the tongue in order to feed the arc. The feed action of this lamp is extremely delicate.

It would be impossible, in the scope of this paper, to dwell on the *hydrostatic feeds*, on the various modes of producing *vibrating feeds* and *hammering feeds*, which have been from time to time suggested. The notion of having a *continuous* feed, the rate of which should be varied as required, is an enticing one, but it has never been made a practical success. Neither have the periodic methods of feeding, at which Mr. Brockie made so brave an attempt in 1881; the flavour of which

indiscretion still clings about him in spite of the admirable lamps which he has produced in later years. Mr. Brockie's various forms of arc lamp would indeed well illustrate the whole range of the subject, and the same thing might be said about the numerous successive types of lamp produced by Mr. Crompton. Mr. Brockie has lately produced an excellent little projector lamp for use in the optical lantern, having the negative carbon pressed by spring against abutment screws of steel, whilst the upper carbon is fed forward by a nipping-lever controlled by a solenoid. *Abutment* lamps and *projector* lamps form separate classes by themselves, which cannot here be discussed.

Many of the points alluded to in the preceding descriptions are illustrated by the action of the De Puydt lamp, Fig. 23. This is a rack-train lamp which strikes its arc by lowering the lower carbon and raising the upper simultaneously, and feeds with a fly and detent controlled by a shunt-magnet. The main-circuit magnet, M, attracts obliquely its armature, rocking the train of wheels around the pivot of the first wheel. A lever, L, bent to an elbow which rests on the set screw, V, is also pivotted around the same arbor, and has a vertical arm which carries two attachments; a fork which engages on a pin on the train-frame, and a detent which arrests the fly. The other end of the lever, L, is held back by a spring, but can be attracted up by the shunt-magnet, S, when the detent is to be released in order to feed.

Product-Regulation.

Before passing away from the feeding mechanisms, we may return to the question of regulation in general, and in particular to the point that the function of the mechanism of the lamp is to maintain constant one of the two factors of the electric energy, the dynamo being responsible for the other. That part of the electric mechanism which controls the feed is responsible for the steady working of the lamp; and it is this which has to be sensitive to the fall of the current (in constant potential lamps), or to the rise of the potential (in constant current lamps). It is this which must control the feeding mechanism of the lamp. It may be remarked that the striking electromagnet represents the muscle of the lamp, but the feeding electromagnet represents the brains. Now, if the brains of the lamp have to think about, and control, one factor in the product, why can they be not made to think about and control the product itself? Such a lamp, in

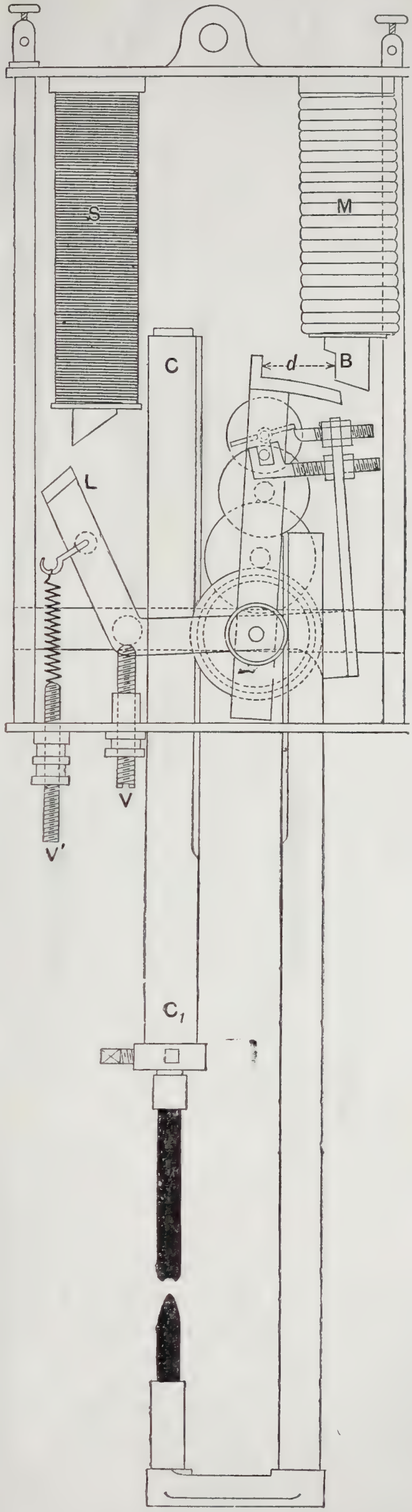


Fig. 23.—De Puydt's Lamp.

which the controlling part is neither an ampère-meter (main circuit) device, nor yet a volt-meter (shunt) device, but a watt-meter device, ought to make the lamp independent of any fluctuations in the supply. Product regulation is clearly in the abstract better than regulation either by the ampères alone or by the volts alone, or by the difference between them; and the mechanism is certainly such as can be constructed. Such a lamp ought to run on any circuit. Let it be remembered that on a constant potential circuit a shunt-magnet can do no more than a spring might do. Neither can a main-circuit magnet in a constant current circuit do do more than a spring. A lamp in which both coils are properly combined, ought to be capable of working on either kind of circuit. Indeed, there are some existing lamps which will very nearly do so.

Relay Lamps.

It is evident that the brains of the lamp

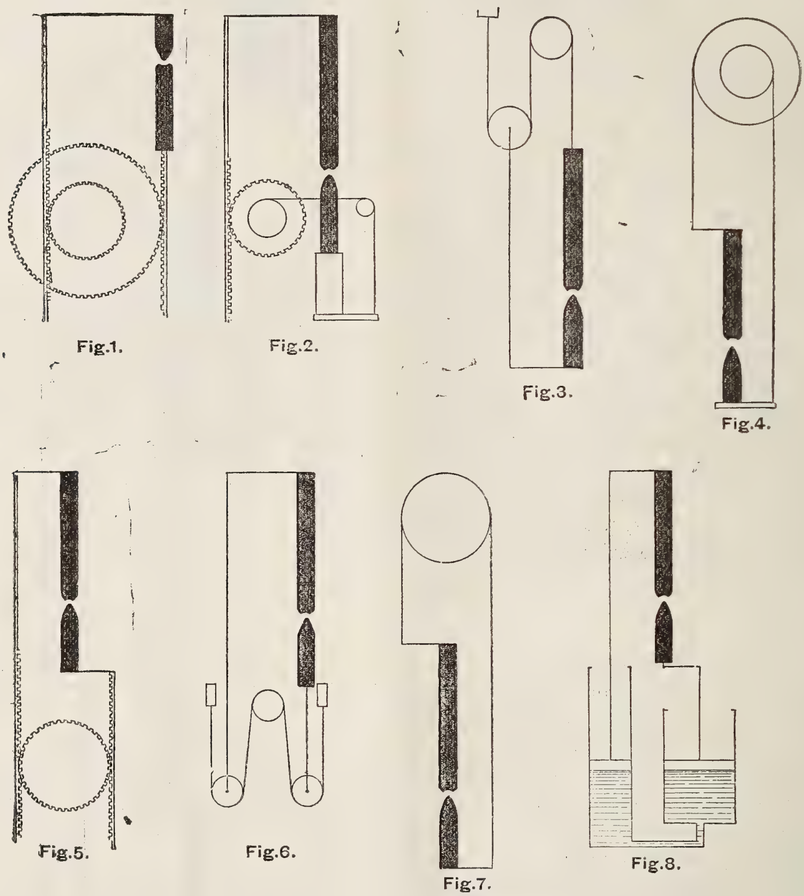


Fig. 24.—Modes of Focussing.

need not necessarily be placed inside the lamp itself; the device of using a sort of *relay*, outside the lamp, to watch the lamp and control its feed, is one that has been frequently suggested [Crompton, Abdank, Gerard, &c.]. There is one lamp [Jolin, 2570[83]]. in which a shunt relay, itself too weak to move the feed tilting-plate, does the work by opening and closing one of the circuits of a double, differentially-wound, main-circuit electromagnet.

Retarding Mechanisms.

It would be very easy to write a whole chapter on fans, air dash-pots, glycerine dash-pots, and the innumerable devices which have been tried. Two are worthy of mention, namely, Hopkinson's device [153[81]] of altering the rate of feed by raising or lowering mercury in a vessel in which a fan is continuously rotating, and Brockie's suggestion of a liquid brake-wheel containing internal partitions, communicating by small apertures, so that a

liquid could flow but slowly from one chamber to another.

Replacement Mechanisms.

These may be classified as follows :—

(*a.*) In rack-train lamps, a ratchet-wheel on first or second member of train.

(*b.*) In clutch-lamps with loose clutches, none required.

(*c.*) In forward-feeding clutch-lamps, some device for loosening the clutch.

(*d.*) In screw-feed lamps, some device for unclamping the screw gearing.

Focussing Mechanisms.

The various ways of giving to the carbons the desired differential rates of approach are best classified by reference to Fig. 24, which gives four methods of producing a motion of the carbons in the ratio of two to one, and four methods of "commercial focussing," in which the carbons are moved toward one another at equal rates.

Change-over Mechanisms.

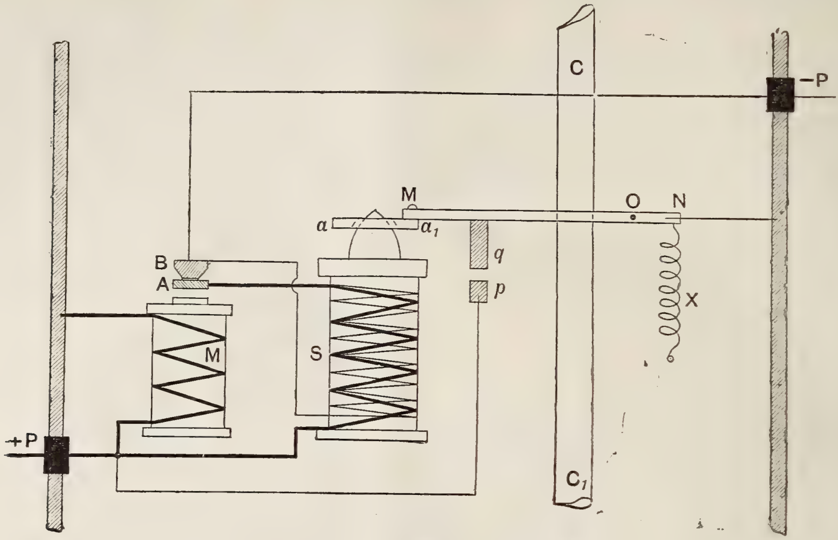
These may be classified into those which are purely mechanical [Brush, Thomson-Rice, Bürgin, Crompton-Crabb, &c.], and those which are electrical, the current being switched off from one pair of carbons, and switched on to another [Weston, 1163^{82}; Waterhouse, 5185^{81}; Trott and Fenton, 6910^{87}; Noble, 16376^{87}; &c.].

Cut-out Mechanisms.

"Cut-out" mechanisms may also be purely mechanical; but they are more usually electrical, and, in modern forms, enable the lamp to "cut-in" again, on the re-establishment of its proper circuit. Cut-outs which enable a shunt-magnet to strike and feed the arc are described by Lever [8443^{84} and 11501^{84}], and are used in the Thomson-Rice lamp. The latest devices are those of Lauckert [5707^{87}], and Phillips and Harrison [7235^{87}]. In many lamps the cut-out circuit is merely a shunt electromagnet stiffly set, which, on the failure of the lamp, receives the whole current, and pulls over a cut-out switch. Gerard [4792^{81}] describes several such devices, as well as a cut-out depending on expansion by heat. In the Pilsen lamp (Fig. 21), the cut-out is in an auxiliary main-circuit. Cut-outs depending on the fusion of a wire or of a washer have been proposed by Lontin [2094^{77}], Basilevsky [5026^{84}], and McDill [1887].

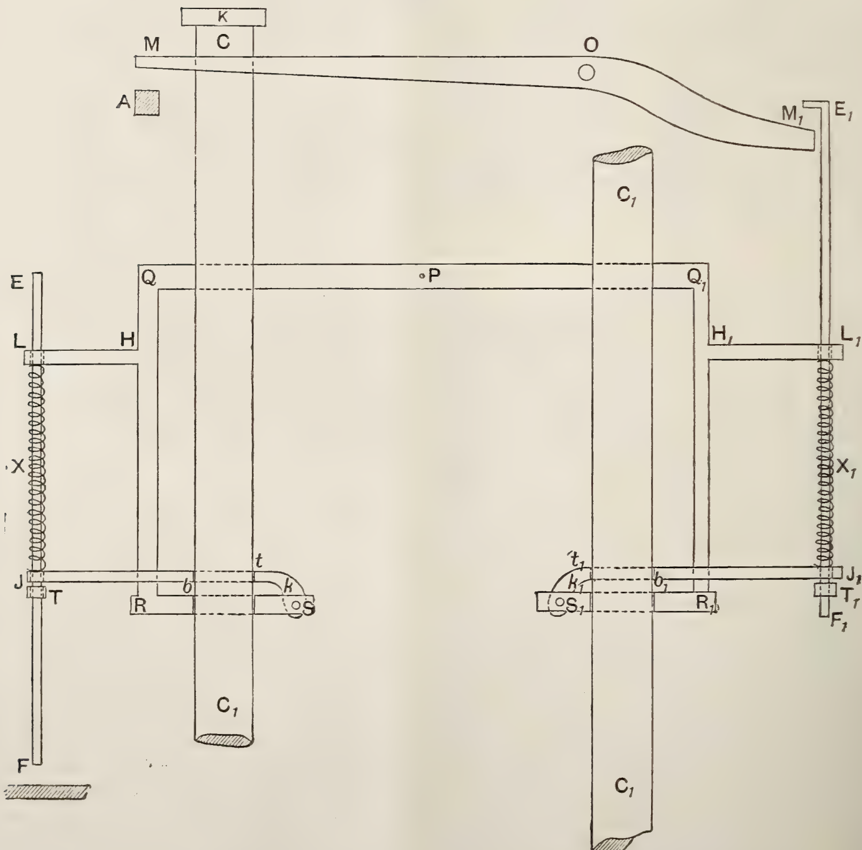
The action of change-over and cut-out mechanisms is well illustrated by reference to the Thomson-Rice lamp, of which Fig. 25 (p. 356) illustrates the electrical mechanism, and Fig. 26 (p. 356) the mechanical mechanism of the lamp. The terminals are marked + P and − P. The carbon rods, C C and C_1 C_1, are held up by their respective clutches, which are identical with those of the Thomson-Houston lamp (Fig. 14) already described. The clutches, when the lamp is not at work, are themselves held up by the spiral springs, X X, which push down the levers, J and J_1, and push up the arms, H L and H_1 L_1, so gripping the rods. The principal electromagnet, S, with its conical poles, has a pierced armature, *a a*, mounted on the end of a strong lever, M N, (Fig. 25), which is pivotted at O, the short tail, O N, being pulled down by a powerful spring, X. This lever, thus held up above the poles of the electromagnet, is connected to point P (Fig. 26) of the clutch-frame, and holds it up. The adjusting nuts of this frame are so set that when P descends the lower end, F, of the pin, E F, strikes on the base plate and opens the clutch for the left carbon-rod, so striking the arc of this pair of rods. When the pencils of this side are consumed, the rod, C C, has descended so far that its projecting head, K, strikes the long lever, M M, the other end of which raises the pin, E F, so bringing the other clutch into action. The electric arrangements, Fig. 25, are as follows:—The magnet, S, is wound with a few turns of thick wire, and with many turns of fine wire. The cut-out (or cut-in) magnet, M, is wound with coarse wire only. The upper carbon-rod is connected electrically to the frame of the lamp, whilst the lower carbon, insulated from the frame, is joined by a wire (not shown in the figure) to the negative pole. The current entering at + P passes first round the coarse wire on S, most of it going through A and B (which are in contact), and on to − P; but a little of it, after traversing the coarse wire coil, turns back along the fine wire coil and goes by this by-pass route to B and − P. As a result, the armature is strongly attracted, and the lever M N descends, causing the carbon-rod to drop. This now opens another route for the current. Starting at + P, some of it will flow through M to the frame, thence through the upper and lower carbons and so to − P. This current will attract the armature A, and break the contact between A and B, breaking the coarse wire circuit through S, leaving the fine wire path still available.

FIG. 25.



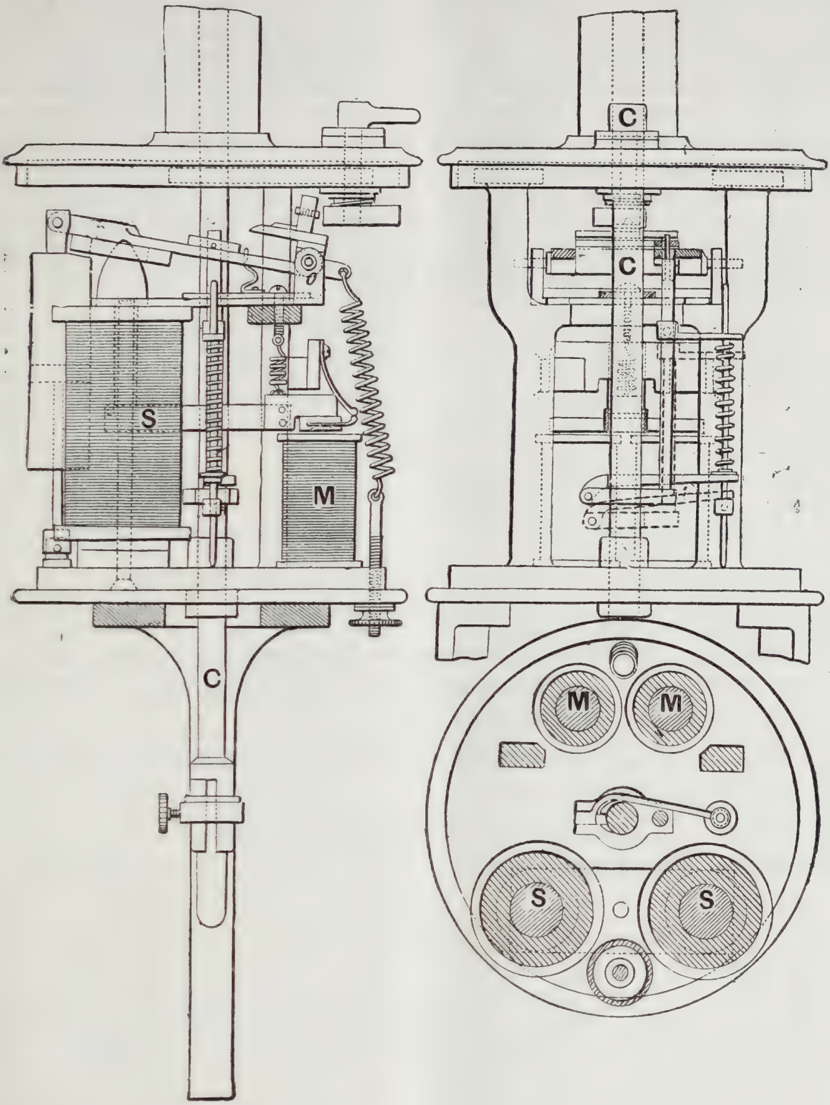
CIRCUITS OF THOMSON-RICE LAMP.

FIG. 26.



MECHANISM OF THOMSON-RICE LAMP.

FIG. 27.



GENERAL VIEW OF THOMSON-RICE LAMP.

M. The cut-out (or cut-in) electromagnet which opens the contacts of the coarse-wire winding on the electromagnet, S.

S. The principal electromagnet, wound with fine and coarse wire. The armature of this electromagnet is attached to a lever pivotted at O, and held at its other end by a strong spiral spring. This armature, in sinking, opens the clutch, and, in rising, closes it on the carbon-rod which it raises.

Consequently S loses most of its power, and the spring X pulls up the lever M N, so striking the arc. The shunt-circuit (fine wire) through S is still at work, and continues to operate the feeding, increasing as the resistance of the arc lengthens.

The present attempt to furnish a classification of the various mechanisms, electrical and mechanical, of the arc lamp, is probably extremely imperfect, but it may at least claim to supersede the old and ludicrous division of lamps into "monophotal" and "polyphotal." In conclusion, it may be pointed out that there exists a curious sort of family likeness between the several members of the three species of lamps most in use. The rack-train lamps, which may be considered as the prevailing continental type, are for the most part, in their design and construction, essentially clockmakers' lamps; they have a horological aspect. The clutch lamps so universal in America have a sort of sewing-machine look, the working parts being only finished where necessary for actual work, all else being left rough or merely painted over. The clutch-wheel lamps favoured by British inventors have, in contrast to these, a look as though they had been designed and constructed by a trained engineer; they are essentially engineers' lamps.

APPENDIX.—Sample of Filling up of Schedule.

SCHEDULE OF ARC LAMP MECHANISM.

Name of Lamp.—Thomson-Houston. Single arc.

Nature of Supply.—Constant current; *ampères* 9·8.

Resistances.—*Main-circuit coil*, 0·09; *shunt*, 279; *cut-out* 0·85 *ohms*.

A	*Driving power*......	Gravity on upper carbon-rod.
B	*Striking*	Main-circuit electromagnet attracts lower end of see-saw, lifts clutch.
b	*ditto adjustment*..	(1.) Special resistance-coil shunting main-circuit coil. (2.) Spring on tail of clutch.
C	*Feeding*............	Shunt electromagnet attracts upper end of see-saw, lowering clutch.
c	*ditto adjustment*	Same as *b*.
D	*Moderating*	Air dash-pot on horizontal tail of see-saw.
E	*Replacement*........	None required.
F	*Focussing*..........	None.
f	*ditto adjustment*	None.
G	*Change-over*........	None.
H	*Cut-out*............	Insulated contact on lower end of see-saw, pulled over by shunt-coil, and puts cut-out resistance as shunt from + to – terminal.

DISCUSSION.

Mr. P. Sellon said it must have been a pleasure to all to listen to Professor Thompson's wonderfully clear and lucid paper; and the question he had brought forward was particularly interesting just at this epoch of electric lighting. Arc lamps were very prominent in electric lighting some eight or ten years ago, but since then there had been a general lethargy both on the part of electrical engineers and the public in regard to them, the development of the incandescent lamp and the systems of distribution having almost monopolised attention. But just at this time, when electric lighting appeared about to have a chance at last, when they were really looking forward to a legitimate expansion in electric lighting from central stations, and might hope to see the streets of London and other large towns lighted in a way which would compare with towns in America and on the Continent, they were much indebted to Professor Thompson for again bringing forward this question of arc lighting. The question he had raised about the back electromotive force of the arc, or what was supposed to be back electromotive force, was a point well known to electrical engineers, and several theories had been advanced to explain the phenomenon: it would seem as if it was a number of

thermo-electric couples between what the Professor told them was the point of volatilisation necessary in an arc light, and the atmospheric temperature, so as to make up the 39 or 40 volts of the back pressure. With regard to the classification which Professor Thompson had given, he might perhaps be prejudiced in the matter, but he thought the distinction drawn between clockmakers' and sewing-machine makers' lamps, and engineers' lamps, was rather hard. He always classified lamps in his own mind as broadly divisible into two kinds—the arc lamp, which was non-retractile, and which was generally a lamp with electromotive force feed alone, the striking being done by an independent magnet or mechanism, the effect of which was that, as the release of the feeding mechanism required very little power, lamps of that order were exceedingly sensitive; and, speaking broadly, they had far greater steadiness than in the other class, in which the electromagnet had to do the double operation, not only the heavy work of striking the arc, but the light work of feeding the mechanism. Both these had their advantages. The latter were retractile; the other class were non-retractile, but, speaking generally, were more likely to give an absolutely unwavering light. The non-retractile might be called an egoistic lamp, and the other he considered as an enlightened altruistic lamp. The egoistic one, if put on a circuit with an altruistic one, would take great care to select for itself the amount of electromotive force required, and the more virtuous altruistic gentleman suffered in consequence. The effect had been that many altruistic lamps had got a bad name undeservedly, because the egoistic lamp would either burn exceedingly well or not at all, and unless the electromotive force furnished by the dynamo was sufficient for all the lamps on the circuit, they would go out entirely; but the altruistic ones would adapt themselves to varying conditions, and burn, though not so well, with an insufficient current; and as the tendency of human nature was to take as little trouble as would produce a passable result, want of attention had often given the latter a bad name. It was a case of external neglect rather than one proper to the lamp itself. Professor Thompson's course of reasoning seemed to have led him to a watt-regulated lamp as the beau ideal of what an arc lamp should be; and no doubt that was perfectly true, following that line of reasoning; but surely it should be remembered that arc lamps invariably ran either with a constant electromotive force or with constant current, and if you are dealing with either one set of conditions or the other, what function did the watt regulator fulfil? An arc lamp, in order to burn reasonably well, must have somewhere between 45 and 50 volts at the terminals, and it was no satisfaction to that lamp, if the electromotive force fell to, say, 40 volts, to know that it would raise the current up so as to bring the product of the electromotive force by the current to a given number of watts. Those who called themselves practical men had a tendency to think lightly of the work of professors, and to suggest that they merely served up a *réchauffé* of past history, and that it was the practical man who made all the advances. He did not hold that view himself, and it was quite impossible to justify it on listening to any of Professor Thompson's papers. He never listened to him on any subject without being struck by the way in which he not only carried his hearers' minds through a concise train of reasoning as to the past history of the subject, but also made practical suggestions, and gave narrowly-defined lines upon which a genuine advance could take place in the future.

Mr. ROGERS also thought Professor Thompson had been a little hard on some of the clutch-lamp makers; though it was some comfort to hear that if the lamps were rough, they were effective. All who had to do with the placing of lamps of that rough and ready class, knew that there were certain conditions which Professor Thompson had explained, which did not appear at first sight, which had to be attended to. However well you might make your moving part, after a time either the rod was abraided, or dirt got in and impaired the steadiness of working. He had experimented with some 20 or 30 different forms of clutch, and always found that was the main difficulty to get over. The motor-driven lamp referred to last he had been much struck with, but should like to ask one question about it. He believed some eight or nine lamps of the motor type had been made, but after some time there was a defect, which he thought he had noticed in that one; although it was exceedingly steady. After a time the lamps got warm, and then there was a tendency to retardation in the motor. In watching the lamp, he thought the later feeds—and there seemed about a couple of dozen feeds in all—were a little retarded, the arc became a little longer before it began to feed, but he did not know whether it was due to the cause he had suggested. One such lamp was in the Crystal Palace Exhibition, and he rather fancied it had the same defect, but this was certainly the most perfect thing in the shape of feed he had yet seen.

Mr. R. J. WILLIAMS said he was not connected with any company, but he had had a little experience in putting up lamps, and he must say that he had found what were termed the rough and ready lamps the best in some cases, simply because you were obliged, in foreign countries, or in exhibitions, or in cases of emergency, to employ the workmen you could get on the spot, who were not always very skilled, and were often working under conditions in which dust and dirt were unavoidable; and in such cases the sewing-machine type (American) of lamp, did its duty quite as well as any other, and, he thought, rather better, though he would not state that positively. He had chosen the Brush type of lamp, or one similar to that, for the lighting of the Kremlin at the time of the coronation of the Czar.

He used them with rough Russians in the coldest of climates, and again in the hottest of summer weather, and, under both conditions, they did their makers credit.

Mr. MORDEY thought the great difficulty with lamp manufacturers had been that they wanted to make one lamp which would do for every purpose. Many of these lamps would not answer, except, perhaps, under one set of conditions; but a lamp ought to be able to burn in series, parallel multiple series, constant current, constant electromotive force, and with an alternating current or continuous one, and manufacturers wanted to make one lamp which would do all these things. It would facilitate their work very greatly if they could turn out an article which would only want modifying in detail to effect all these objects. That was the reason why, though he had been connected with electric lighting a great deal, he had never tried to invent a lamp, and he was probably the only man in the room who had not. But in fact he was rather tired of it; he was connected with the Brush Company, and as he found that under any passable conditions, given good carbons and fair treatment, the Brush lamp would burn at least as well, and taken all round, better than any other, he thought it as well to leave it severely alone.

Mr. WYLES said the Brush lamp burned very well at first, but then the rod got a little speckled; and he thought the fault lay in sending the current through the washer; and that if the connection were so arranged as not to have a moving contact, it would be better. The new form of Brush lamps was a great improvement on the old ones. With regard to the Brockie-Pell lamps, he found them work admirably; the electromotive force was practically constant, and he did not quite follow Mr. Sellon when he said they robbed the others if worked on the same circuit, assuming them to be working with the average electromotive force on the circuit. He should be glad if Professor Thompson would explain the connections of the Maquaire lamp. His experience was that the Crompton lamps required much more skilled workmen to attend to them, but they burned very well if properly attended to.

Professor THOMPSON, in reply, said he was not quite sure that he understood Mr. Sellon with regard to the egoistic and altruistic lamps, but he did not agree with what he took to be his meaning. He did not think you could divide lamps which had only one magnet from those which had both series and shunt magnets, and call them egoistic and altruistic. In the case of a constant potential, you did not require two magnets to get a retractile effect. For example, there was the Gülcher lamp, with a magnetic clutch, in which a single magnet fed and struck, and could move up or down, according to the requirements of the arc. It was retractile, and yet there was only one magnet. On the other hand, he could point to a lamp which had two magnets —a pot-magnet at the bottom to strike the arc, and another one at the top to regulate the feed with a shunt—which had nothing retractile about it, although there were two magnets. Why one should be called egoistic and the other altruistic he did not know. One would undoubtedly adopt itself to the conditions of the arc, and the other would not, but it was the altruistic one in this case which did not adapt itself to the surrounding conditions, and the egoistic one which did. He must beg pardon of Mr. Sellon and Mr. Rogers for having dared to compare the lamps of the companies they represented to the work of clockmakers or sewing-machine makers, but he would ask them whether the criticism was not in the main just; whether the class of lamp, as a whole, had not that characteristic about it. It was quite possible to have a sewing-machine well made, and quite possible to have a clock which was a magnificent piece of engineering, not thrown together like the clocks which inundated the market from abroad. But he would remark, that not only was the voltaic arc itself discovered by an Englishman, Sir Humphrey Davy, but the first rack-train lamp was invented by Staite in 1847, and the first clutch by Slater and Watson in 1852; whilst, as for clutch-wheel lamps, we must claim them all. They were all equally English from this point of view: and it was perhaps rather characteristic of the people where they were used, than of the inventors, that the Americans seemed to have adopted the clutch and the Continentals the rack and train. It was not for him either to condemn or to approve without reserve any one lamp, or to say which, of all he had mentioned, he gave the preference to. If any one wished to know which he considered the best, they would have to read very carefully between the lines of his paper; as a matter of fact, there was no best lamp, or, at any rate, he had not yet found it; but there were some which, take them for all in all, might be said to be as good as any other in the market, and there might be two or three for which that claim might fairly be made. Mr. Sellon objected to his notion that regulating by the product—by the watts instead of the volts or ampères—was possible, because arc lamps were habitually worked with constant potential or constant current. He quite agreed that theoretically you got over the variation in the quantity of energy supplied by having a mechanism which provided for the regulation of the one factor; but there were certain lamps which did not depend either on the current or on the potential, but on the difference between the two; the lamps being differentially wound. In fact, the differential winding, to keep the difference between the two quantities, instead of the product, constant, was one of the things which had been looked upon in the past as an important patent. Did not Mr. Sellon's argument apply still more strongly to such a form of lamp? If one

of two factors of the product was constant, you kept the difference between that and the other constant, you virtually kept the product constant; but if, with one of the two supposed constant, you could not depend on the dynamo, then the difference between that and the other being kept constant would not regulate the light at all; the difference failed to have any meaning if you could not rely on one of the two things, between which the difference was to be taken, being constant. The attempt at product regulation was therefore essentially better than regulation by difference. With reference to the connections of Maquaire's screw lamp, it was difficult to explain them off-hand, but he would endeavour to give some of the method. The large magnets must be taken as being wound in the main circuit with thick wire; but when you had got half-way through the winding, there was a branch taken off, which went to one of the brushes of the armature. This had a comparatively fine wire coil, and was virtually a volt-meter. This was, therefore, necessarily, a product-regulating lamp; because, if the armature were a volt-meter, the field-magnets were in the main circuit, and were a sort of ampere-meter, the force which pulled the thing round would be proportional to the product of the two. But this was not a watt-meter in the proper sense of the word, because the armature was not taken as a shunt to the whole arc; it was only taken as a shunt to half of the coils of the field-magnets. (Professor Thompson further explained the mechanism of the lamp by the aid of a diagram.) Mr. Rogers said he thought that he had watched the lamp feed about twenty times, but he thought he must have been mistaken, because the little armature did not remain constant more than 10 seconds together when the lamp was in operation, the regulating wheel was continually in motion, the one revolution of the wheel made an extremely small difference in the position of the carbons. (The lamp was again put in operation to illustrate this.) He did not think the heating of the motor, as suggested, would seriously affect its performance, and he did not see why it should affect this mechanism any more than the operation of a clutch. He thoroughly believed in a rough and ready lamp for rough and ready work; but rough and ready work, such as was admissible in illuminating the Kremlin or lighting a "city" in the back-woods of America, was not the kind of work which would be sufficient when a contract for lighting the City of London had to be fulfilled.

The CHAIRMAN, in proposing a vote of thanks, said all Professor Thompson's work was characterised by great patience and immense industry; some of the papers he had read in that hall had become quite classical, and, in particular, the one on dynamo-machinery had developed into the best book on electro-dynamos in the world. One or two new points had been raised that evening which required a considerable amount of development. For instance, this theory of the back electromotive force, which had occupied as yet the labours rather of the laboratory than of the practical man, had behind it an immense amount of practical importance. At present, they did not know to what to attribute it, and it was extremely variable. The lamps on which the principal experiments had been made were Brush lamps, and the best experiments were those made by Professor Cross and Mr. Shepherd, at Boston, on Brush carbons. Those made by Mr. Edlund were on Carrè carbons from Paris, but he knew it to be a fact that this back electromotive force was extremely variable, according to the quality of the carbon. Mr. Crompton, some years ago, made a series of observations on the light-giving qualities of various kinds of carbons; his researches were published in Mr. Gordon's book on electric lighting, and he there brought out some astonishing results. For instance, with the same amount of current the amount of light varied very much indeed. Those who had the opportunity should certainly attack this question, and those who did would find that in regard to the quality of carbons there was a wide field for experiment. Professor Thompson had not said much on the immense importance of having steady arc lamps for alternate current working, but that was coming to the front with giant strides. We were on the verge of a tremendous boom in electric lighting, and before twelve months were over he believed every one would be astonished at what was done in London. He knew at present of ten central stations which were in progress, most of which would be at work within a year, and he had every reason to believe that by that time all the principal thoroughfares in the City—with the Strand and Piccadilly—would also be illuminated by arc lamps. The selection of these lamps would involve a great deal of care and consideration; and although some remarks had been made on Professor Thompson's classification, he thought it might be justified. Clockwork was but machine or engineering work, and he ventured to think that the highest compliment which could be paid to any class of work was to compare it to a sewing-machine. There was no piece of mechanism in the world so wonderful as a sewing-machine. They were worked for years in kitchens and all sorts of places by unskilled persons of all kinds, and did their work well. Six months ago he had the first Graphophone sent to this country; it was exhibited at Bath; from there he brought it to his office, and it had been in constant use since September. It had been handled by everyone who liked, and when he took it home at Christmas, it was worked by all his children, and by everyone who saw it, and it had never been out of order once. That instrument was a grand specimen of sewing-machine work, and a more beautiful piece of mechanism was never brought to this country. He trusted this paper would become as classical as its predecessor, and that it would develop into a hand-book on arc lighting.

The vote of thanks having been passed unanimously,

Professor THOMPSON, in response, said he would take that opportunity of thanking all the gentlemen, too numerous to mention, who had so kindly given him information, and lent him lamps for exhibition.

The following lamps were exhibited, and most of them shown in operation:—Serrin, Brush-Sellon, Crompton "E," Brush (2), Thomson-Houston, Thomson-Rice, Waterhouse, Lever, Gülcher, Jolin, Fein, Crompton-Crabb "D.D.," Statter, Brockie (Projector), Pilsen, Rogers, Maquaire, Siemens (Contact), Siemens (Projector).

Miscellaneous.

TELEPHONIC DEVELOPMENT IN EUROPE.

The Secretary of State in the Department of Posts and Telegraphs in Germany has recently, says the *Journal de la Chambre de Commerce de Constantinople*, issued a series of reports upon the extension of the telephone and the telegraph. It appears from these reports that the total length of telephonic lines throughout the world is 966,900 kilometres (the kilometre is equivalent to ·621 of a mile). The wires themselves have a length of 2,724,000 kilometres. More than half these kilometres—that is, 538,500—belong to Europe, and out of this number Germany counts for 84,736 kilometres, with 283,967 kilometres of wires. The submarine cables, to the number of 950, have a total length of 112,700 geographical miles. The total number of telephonic apparatus in actual use throughout the world amounts to 160,000. At the end of 1887, there were 164 telephonic lines in Germany. The number of subscribers in Berlin at the same period amounted to 8,597, a figure which has since been considerably increased. In New York there were 6,902 subscribers; in Paris, 5,330; in London 4,596, and in Vienna 1,200. At the present time in Vienna the development of telephonic communication has been attracting considerable attention for some time past; the establishment of a telephonic communication between Vienna and Prague is virtually decided upon by the Austrian Government, and the line will be kept quite distinct from the telegraph lines. Other lines will shortly be constructed in Austria, with a view of putting Prague into communication with Teplitz, Reichemberg, Brunn, and all the large manufacturing towns of Bohemia. The system of the Austrian Telephone Company of Vienna is rapidly extending; it has at the present time 2,500 subscribers, and wires are being laid for 800 fresh subscribers. The Austrian Government opened, on the 26th November last, a telephone station at Warnsdorff, an important manufacturing town in Bohemia. In the present year offices will be opened at Salzbourg, Gablouz, Carlsbad, and several other towns; but it is the intention of the Government to devote greater attention to the development of the system of inter-urban communication. There are at the present time 33,000 telephone stations in Germany, 4,200 in Austria-Hungary, 4,647 in Belgium, 1,857 in Denmark, and 2,218 in Spain. France has only 28 telephone systems, of which 2 are in Algeria, while Germany has 164. At the commencement of 1888 the number of subscribers in France amounted to 9,847, and in Germany to 33,000. The United Kingdom had 122 systems with 20,426 subscribers; Italy 28 systems with 9,183 subscribers, of whom 1,835 were in Rome, 1,213 at Milan, 992 in Naples, and 748 in Florence. In Luxemburg there were 15 lines with 483 subscribers; in Norway 9 lines with 2,872 subscribers; in Portugal only 2 lines, one of which is at Lisbon, and the other at Oporto, with 541 and 349 subscribers respectively. In Russia telephones have also been introduced. There are, in that country, 36 systems with 7,589 subscribers, of whom 1,500 are in St. Petersburg, 700 at Warsaw, 840 in Moscow, and 700 in Odessa. Sweden has 137 lines and 12,864 subscribers. Switzerland in 1888 had 71 telephone lines with 7,626 subscribers, of whom 1,533 are in Geneva, 1,066 in Zurich, 926 in Bâle, and 544 in Lausanne. In the latter country telephony tends to exhibit a very considerable development, and the *Journal Telegraphique* of Berne, states that the Federal Council has recently presented to the Chambers, a proposal for the regulation of subscriptions to the telephone on all the Swiss systems. According to this proposal, the tariff would be fixed at 120 francs for the first year, 100 francs for the second, and 80 francs for the third and following years. This rate, however, would only give the right of 500 conversations a year, and over and above this number a supplementary payment of 5 francs per 100 communications would be required. As regards the length of the conversation between various towns, this would be fixed at three minutes. The exceptional development of the telephone in Germany dates principally from the invention of the microphone, *Mix* and *Genest*, of which nearly 30,000 have been supplied during the last two years to the Department of Posts and Telegraphs, and to the public generally.

General Notes.

PARIS THEATRES IN 1888.—The French *Administration de l'Assistance publique* has recently published a statement showing the receipts of the Paris theatres

for the year 1888. From this statement it appears that the total amounted to 23,007,074 francs against 22,062,440 francs in 1887, the year in which the catastrophe at the Opera Comique occurred. From 29,068,592 francs in 1882, the receipts fell to 25,074,458 in 1886. The receipts, although they have fallen, are still higher than they were some twenty years ago; for example, in 1869 they amounted to only 15,198,000 francs. They then rose, until in 1876 they attained the figure of 21,663,662 francs, while in 1877, the year of the exhibition, they amounted to 30,657,449 francs against 21,983,867 in 1867, and 13,828,123 in 1855, years in which exhibitions were held in Paris. If the same proportion continues, it is stated that the receipts of the Paris theatres will approach 40,000,000 francs (£1,600,000).

Canadian Asbestos.—The mines of this mineral are all situated in the Eastern townships province of Quebec. Ten years ago the shipments were only 300 tons, last year they reached 4,619 tons. Except 400 tons the whole of this is from Quebec, and mined by ten, different producers at Thetford, Black Lake, Danville, and Coleraine. In Ontario 400 tons of a somewhat different article, and used principally for asbestos roofing, were produced at Bridgewater.

Exports of Russian Grain.—The Russian Ministry of Finance has recently published statistics, showing the exports of cereals during the last three years. The following statement shows the quantity in pouds—1 poud = 36 lbs. avoirdupois:—

	1886. Pouds.	1887. Pouds.	1888. Pouds.
Wheat	79,335,000	118,617,000	183,927,000
Rye	59,948,000	72,710,000	99,501,000
Barley	33,192,000	48,353,000	65,270,000
Oats	33,763,000	59,666,000	86,804,000
Maize	19,694,000	26,514,000	15,836,000
Other kinds	13,372,000	18,189,000	28,164,000
Total	239,304,000	344,049,000	479,502,000

Three-fourths of these quantities were exported from the Southern Ports, Odessa, Rostov, Nicolaiev, &c.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday evenings at Eight o'clock:—

March 13.—"Aluminium and its Manufacture on the Deville-Castner Process." By William Anderson, M.Inst.C.E. Prof. Sir Henry Roscoe, F.R.S., will preside.

March 20.—"Objects and Methods of the Society of Arts' Motor Trials." By Prof. A. B. W. Kennedy, F.R.S. The Duke of Abercorn will preside.

Papers for which no dates have as yet been fixed:—

"Fruit Growing for Profit in the Open-air in England." By W. Paul, F.L.S.

"The Sanitary Functions of County Councils." By Sir Douglas Galton, K.C.B.

"Automatic Selling Machines." By J. G. Lorrain.

"Secondary Batteries." By W. H. Preece, F.R.S.

"The Use of Spirit as an Agent in Prime Movers." By A. F. Yarrow.

Foreign and Colonial Section.

Tuesday evenings, at Eight o'clock:—

March 26.—"Borneo." By Robert Pritchett.

April 2.—"The Argentine Republic." By F. K. Smythies.

Applied Art Section.

Tuesday evenings, at Eight o'clock:—

March 19.—"The Art of the Jeweller." By Carlo Giuliano. Sir George Birdwood, K.C.I.E., C.S.I., will preside.

April 9.—

May 14.—"Venetian Glass." By Dr. Salviati.

Indian Section.

Friday evenings, at Eight o'clock:—

March 8.—"The Present Condition and the Prospects of Indian Agriculture." By Prof. Robert Wallace.

March 29.—"The Progress of the Railways and Trade of India." By Sir Juland Danvers, K.C.S.I. Sir George Bruce, P.Inst.C.E., will preside.

May 3.—"The Karun as a Trade Route." By Major-General Sir R. Murdoch Smith, K.C.M.G.

May 24.—"Indian Wheats." By John McDougall.

Cantor Lectures.

The following courses of Cantor Lectures will be delivered on Monday evenings at Eight o'clock:—

Walter Crane, "The Decoration and Illustration of Books." Three Lectures.

Lecture II.—March 11.—Examples of transition—Illumination with printed text—Engraved ornaments and outline pictures intended for illumination—Block books—Examples from the British Museum—The Mazarin Bible—The Mentz Psalter, 1457—The first example of colour printing—French books of Hours by Pigouchet, Hardouyn, and Kerver—Effect

of the classical revival upon book decoration and illustration—Hypnerotomachia Poliphilo, Aldus, 1499—Examples from German, Italian, French, and English printed books in the British Museum—Remarks on their decorative and illustrative value--Development of draughtsmanship and graphic power—Albert Dürer—Hans Holbein—Examples from their book designs—Printer's marks—Emblem books—Alciati—Giovio—Witney—Quarles—The love of figurative art—Use of copperplate—Decorative book illustration—Encyclopædic books—Herbals—Matthioli—Gerard—Decline of beauty and vigour in design and ornamental sense towards the close of the 16th century.

LECTURE III.—MARCH 18.—Of book illustration and ideas of decoration from the 16th to the 19th centuries—Decline of inventive and applied design—Injurious effects of Renaissance traditions—Use of copperplate—Inharmonious combination of with type—Examples—Later designers and illustrators—Hogarth—Stothard—Flaxman—Examples from their works—William Blake—The Book of Job—Benick—Revival of wood engraving as applied to illustrative art—Calvert and other Illustrators—Turner—Steel vignettes—Book illustrators of 40 years ago—W. J. Linton—Effect of the pre-Raphaelite movement—Rosetti as a book illustrator—Modern gift-books—Children's books—Development of—Japanese printed books—Influence of—American development of wood engraving, and American ideas of design and page decoration—Vedder's Rubaiyat of Omar Khayyam—Influence of the photograph—General remarks, and conclusion.

C. V. BOYS, F.R.S., "Instruments for the Measurement of Radiant Heat." Four Lectures.

March 25; April 1, 8, 15.

H. GRAHAM HARRIS, M.Inst.C.E., "Heat Engines other than Steam." Four Lectures.

May 6, 13, 20, 27.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, MARCH 11...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. Walter Crane, "The Decoration and Illustration of Books." (Lecture II.)

Geographical, University of London, Burlington-gardens, W., 8½ p.m. Hon. G. Curzon, "The Trans-Caspian Railway."

British Architects, 9, Conduit-street, W., 8 p.m.

Medical, 11, Chandos-street, W., 8½ p.m.

London Institution, Finsbury-circus, E.C., 5 p.m. Mr. E. B. Tylor, "Marriage Laws—Ancient and Modern."

TUESDAY, MARCH 12...Royal Institution, Albemarle-street, W., 3 p.m. Dr. G. J. Romanes, "Before and After Darwin." II. "Evolution." (Lecture VIII.)

Civil Engineers, 25, Great George-street, S.W., 8 p.m. Mr. F. J. Waring. "Indian Railways; the Broad and the Metre Gauge Systems Contrasted."

Anthropological, 3, Hanover-square, W., 8½ p.m. 1. Professor Flower, "Exhibition of an Artificially Deformed Skull from Mallicollo." 2. Professor Victor Horsley, "Exhibition of Some Examples of Pre-historic Trephining and Skull Boring, from America." 3. Mr. Henry Balfour, "Note on the Use of 'Elk' Teeth for Money in North America.", 4. Messrs. Joseph Jacobs and Isidore Spielman, "The Comparative Anthropometry of English Jews."

Colonial Institute, Prince's-hall, Piccadilly, W., 8 p.m.

WEDNESDAY, MARCH 13...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. William Anderson, "Aluminium, and its Manufacture by the Deville-Castner Process."

Graphic, University College, W.C., 8 p.m.

Microscopical, King's College, W.C., 8 p.m. Mr. J. Deby, *Tsamathiomya pectinata*, a new Dipterous Insect."

Pharmaceutical, 17, Bloomsbury-square, W.C., 8 p.m.

Cymmrodorion, 27, Chancery-lane, W.C., 8 p.m. Rev. H. Elvet Lewis, "The Celt and the Pleasantness of Nature."

Royal Literary Fund, 10, John-street, Adelphi, W.C., 3 p.m. Annual Meeting.

Patent Agents, 19, Southampton-buildings, W.C. 7 p.m. 1. Mr. C. N. Collinson, "Western Australia." 2. Resumed discussion on Mr. E. Carpmael's paper, "A recent important Decision under the Merchandise Marks Act, 1887." 3. Mr. A. J. Boult, "A few remarks upon a recent Decision, 'Longbottom *v.* Shaw.'"

THURSDAY, MARCH 14...Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

Linnean, Burlington-house, W., 8 p.m.

London Institution, Finsbury-circus, E.C., 6 p.m. Mr. Henry Blackburn, "Algeria and Morocco."

Society for the Encouragement of Fine Arts, 9, Conduit-street, W., 8 p.m. Mr. Ralph Nevill, "Tradition or Originality in Architecture."

Sanitary Institute, 74A, Margaret-street, W., 5 p.m. Prof. G. R. M. Murray, "Fungi in their relation to Putrefaction and Sanitation."

Royal Institution, Albemarle-street, W., 3 p.m. Dr. Sidney Martin, "The Venom of Serpents and allied Poisons." (Lecture IV.)

Electrical Engineers, 25, Great George-street, S.W., 8 p.m. Discussion on Prof. George Forbes' paper, "Some Electric Lighting Central Stations in Europe, and their lessons."

Mathematical, 22, Albemarle-street, W., 8 p.m.

FRIDAY, MARCH 15...United Service Inst., Whitehall-yard, 3 p.m.

Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting, 9 p.m. Sir James N. Douglas, "Beacon Lights and Fog Signals."

Philological, University College, W.C., 8 p.m. Mr. E. L. Brandrette, "A Dictionary Sub-Editor's Work."

SATURDAY, MARCH 16...Royal Institution, Albemarle-street, W., 3 p.m. Lord Rayleigh, "Experimental Optics." (Lecture IV.)

Journal of the Society of Arts.

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FRIDAY, MARCH 15, 1889.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CANTOR LECTURES.

Mr. Walter Crane delivered the second lecture of his course on "The Decoration and Illustration of Books," on Monday evening, 12th inst., when he dealt with the illustration of printed books from the invention of printing to the close of the 16th century.

The lectures will be printed in the *Journal* during the summer recess.

THE ALBERT MEDAL.

The Council will proceed to consider the award of the Albert Medal for 1889 early in May next. The medal has been awarded as follows in previous years :—

In 1864, to Sir Rowland Hill, K.C.B., F.RS., "for his great services to Arts, Manufactures, and Commerce, in the creation of the penny postage, and for his other reforms in the postal system of this country, the benefits of which have, however, not been confined to this country, but have extended over the civilised world."

In 1865, to his Imperial Majesty, Napoleon III., "for distinguished merit in promoting, in many ways, by his personal exertions, the international progress of Arts, Manufactures, and Commerce, the proofs of which are afforded by his judicious patronage of Art, his enlightened commercial policy, and especially by the abolition of passports in favour of British subjects."

In 1866, to Michael Faraday, D.C.L., F.R.S., "for discoveries in electricity, magnetism, and chemistry, which, in their relation to the industries of the world, have so largely promoted Arts, Manufactures, and Commerce."

In 1867, to Mr. (afterwards Sir) W. Fothergill Cooke and Professor (afterwards Sir) Charles Wheatstone, F.R.S., "in recognition of their joint labours in establishing the first electric telegraph."

In 1868, to Mr. (afterwards Sir) Joseph Whitworth, LL.D., F.R.S., "for the invention and manufacture of instruments of measure and uniform standards by which the production of machinery has been brought to a state of perfection hitherto unapproached, to the great advancement of Arts, Manufactures, and Commerce."

In 1869, to Baron Justus von Liebig, Associate of the Institute of France, For. Memb. R.S., Chevalier of the Legion of Honour, &c., "for his numerous valuable researches and writings, which have contributed most importantly to the development of food economy and agriculture, to the advancement of chemical science, and to the benefits derived from that science by Arts, Manufactures, and Commerce."

In 1870, to Vicomte Ferdinand de Lesseps, Member of the Institute of France, Hon. G.C.S.I., "for services rendered to Arts, Manufactures, and Commerce, by the realisation of the Suez Canal."

In 1871, to Mr. (afterwards Sir) Henry Cole, K.C.B., "for his important services in promoting Arts, Manufactures, and Commerce, especially in aiding the establishment and development of Science and Art, and the South Kensington Museum."

In 1872, to Mr. (now Sir) Henry Bessemer, F.R.S., "for the eminent services rendered by him to Arts, Manufactures, and Commerce, in developing the manufacture of steel."

In 1873, to Michel Eugène Chevreul, For. Memb, R.S., Member of the Institute of France, "for his chemical researches, especially in reference to saponification, dyeing, agriculture, and natural history, which for more than half a century have exercised a wide influence on the industrial arts of the world."

In 1874, to Mr. (afterwards Sir) C. W. Siemens, D.C.L., F.R.S., "for his researches in connection with the laws of heat, and the practical applications of them to furnaces used in the Arts; and for his improvement in the manufacture of iron; and generally for the services rendered by him in connection with economisation of fuel in its various applications to Manufactures and the Arts."

In 1875, to Michael Chevalier, "the distinguished French statesman, who, by his writings and persistent exertions, extending over many years, has rendered essential service in promoting Arts, Manufactures, and Commerce."

In 1876, to Sir George B. Airy, K.C.B., F.R.S., Astronomer Royal, "for eminent services rendered to Commerce by his researches in nautical astronomy and in magnetism, and by his improvements in the application of the mariner's compass to the navigation of iron ships."

In 1877, to Jean Baptiste Dumas, For. Memb. R.S., Member of the Institute of France, "the distinguished chemist, whose researches have exercised a very material influence on the advancement of the Industrial Arts."

In 1878, to Sir Wm. G. Armstrong (now Lord Armstrong), C.B., D.C.L., F.R.S., "because of

his distinction as an engineer and as a scientific man, and because by the development of the transmission of power—hydraulically—due to his constant efforts, extending over many years, the manufactures of this country have been greatly aided, and mechanical power beneficially substituted for most laborious and injurious labour."

In 1879, to Sir William Thomson, LL.D., D.C.L., F.R.S., "on account of the signal service rendered to Arts, Manufactures, and Commerce, by his electrical researches, especially with reference to the transmission of telegraphic messages over ocean cables."

In 1880, to James Prescott Joule, LL.D., D.C.L., F.R.S., "for having established, after most laborious research, the true relation between heat, electricity, and mechanical work, thus affording to the engineer a sure guide in the application of science and industrial pursuits."

In 1881, to August Wilhelm Hofmann, M.D., LL.D., F.R.S., Professor of Chemistry in the University of Berlin, "for eminent services rendered to the Industrial Arts by his investigations in organic chemistry, and for his successful labours in promoting the cultivation of chemical education and research in England."

In 1882, to Louis Pasteur, Member of the Institute of France, For. Memb. R.S., "for his researches in connection with fermentation, the preservation of wines, and the propagation of zymotic diseases in silk worms and domestic animals, whereby the arts of wine-making, silk production, and agriculture, have been greatly benefited."

In 1883, to Sir Joseph Dalton Hooker, K.C.S.I., C.B., M.D., D.C.L., LL.D., F.R.S., "for the eminent services which, as a botanist and scientific traveller, and a Director of the National Botanical Department, he has rendered to the Arts, Manufactures, and Commerce by promoting an accurate knowledge of the floras and economic vegetable products of the several colonies and dependencies of the Empire."

In 1884, to Captain James Buchanan Eads, "the distinguished American engineer, whose works have been of such great service in improving the water communication of North America, and have hereby rendered valuable aid to the commerce of the world."

In 1885, to Mr. (now Sir) Henry Doulton, "in recognition of the impulse given by him to the production of artistic pottery in this country."

In 1886, to Mr. Samuel Cunliffe Lister, "for the services he has rendered to the textile industries, especially by the substitution of mechanical wool combing for hand combing, and by the introduction and development of a new industry—the utilisation of waste silk."

In 1887, to HER MAJESTY THE QUEEN, "in commemoration of the progress of Arts, Manufactures, and Commerce throughout the Empire during the fifty years of Her reign."

In 1888, to Professor Hermann Louis Helmholtz, "in recognition of the value of his researches in various branches of science and of their practical results upon music painting, and the useful arts."

Proceedings of the Society.

INDIAN SECTION.

Friday, March 8, 1889; Major-General J. MICHAEL, C.S.I., in the chair.

The CHAIRMAN announced that the Duke of Buckingham and Chandos was unable to take the chair on account of indisposition. He said that his Grace much regretted his unavoidable absence.

The paper read was—

THE PRESENT CONDITION AND PROSPECTS OF INDIAN AGRICULTURE.

By ROBERT WALLACE,

Professor of Agriculture and Rural Economy in the University of Edinburgh.

My first duty is a pleasing one, viz., to thank you for having, through your executive, done me the the honour of asking me to address you this evening on such an important subject as the agriculture and the agricultural prospects of our greatest dependency.

The explanation I have to offer for coming forward on this occasion is that I spent the summer of 1887—from early in May till about the middle of September—in India, investigating the agricultural resources of the country, and forming opinions as to the native methods of working, the materials with which they have to deal, and the possibility or impossibility of improving upon them. I have already—about nine months ago—published in detail, in my work "India in 1887,"* what appeared to me to be of the greatest interest and usefulness to the British public. This has placed me somewhat at a disadvantage in the selection of material with which to deal this evening. I obviously could not ignore the facts in relation to the subject before us which nine months ago I considered of first importance; and, from another point of view, it would be unfair to such a vast and important subject to restrict my remarks to what has occurred within the short space of the last nine months.

Agriculture is by far the greatest industry

* Oliver and Boyd, Edinburgh; Simpkin, Marshall and Co., London.

of the Indian empire, and its success or failure is so much bound up with other questions, that it is impossible to do justice to the text without considering the likely issues of certain outside and co-ordinate influences that now affect, and are likely to continue to affect, the interests of agriculture.

It is pretty generally believed that those people were right who assured the English farmers that, although wheat would remain in most years a substantial item in the export trade of India, yet no fear need be entertained of Indian wheat coming to this country in quantities sufficient to swamp our markets. The moderate prospects of the crop yield of this season tend to strengthen this belief.

The first movement which, in the immediate future, is likely to benefit the wheat trade of India, is that for the reduction of the per-centage of "refraction" (or impurities) from 6 or 7 to 2 per cent. The Manchester Chamber of Commerce has agreed to help in the attempt now being made to introduce the smaller per-centage as a recognised trade custom. If the London Chamber of Commerce should continue to refuse to co-operate, and the grievance is not remedied by unofficial means, it appears in every sense to be clearly a case for interference by the strong arm of the law. It has been estimated that the direct loss to the community is equivalent to the sum of £50,000 a-year, spent upon the absolutely unremunerative work of shipping and carrying sand or clay, which had been added to the cleaner samples of wheat with the deliberate object of netting an unjust gain.

A man is punished severely in this country if he adulterates milk with pure water. To add earth to samples of grain is none the less a fraud that ought to be treated by the usual means, after due warning that such practices can be no longer winked at. It is surely a mistake to submit to present conditions in the face of the recent report of Mr. John McDougall—made to the Under-Secretary of State for India—to the effect that "Indian white wheats, when separated from all admixtures, are of a very fine quality, equal to the finest in the world." This goes to show that there is nothing in the prospects of the Indian wheat trade upon which the British farmer can raise his hopes for the future. It is not necessary to flood the market in an exceptional way with wheat to keep prices down to a low level. A moderate addition of wheat of the finer sorts is sufficient, in the light of our experience of the past year, to seriously depress the ruling rates of wheats grown in this changeable climate.

The centre of interest to the British farmer in the matter of the Indian trade with this country is rapidly shifting to other products, which are certain to be sent in increasing quantities, I refer to various leguminous crops — the numerous kinds of peas, lentils, and gram — with which some of our great grain centres are already more or less familiar. In feeding properties they are, when clean, practically equal to home-grown beans and peas, and will, in the immediate future, bulk largely in the purchased foods of the farm for the purposes of both milk and meat production. Cheap Indian pulses and other inferior grains may be looked upon as a blessing to this country, and a something (though admittedly it is poor consolation) upon which the farmer can fall back under the growing pressure of competition on all sides.

The Argentine Republic has quite recently begun to contribute to our meat supply, in addition to former sources of competition. It is perhaps one of the most formidable of all our competitions owing to the enormous wealth of its resources—soil, climate, and people—and the thoroughly business-like way in which the trade with this country is organised and carried on.

The British producer must have cheap feeding materials to enable him to maintain his position against the meat imports from South America, which, as regards quality, are already absolutely undistinguishable from his own. He will find what he wants in the pulse grains of India at a cheaper rate than he is likely to be able to grow them in this country. Precautionary measures against disease may be forced upon those using Indian pulses, as disease of a serious nature (no doubt the authrax of India) has been traced by Principals Williams, of Edinburgh, and McCall, of Glasgow, to their use in horses' food*. I have already, on a previous occasion, pointed out that to maintain the fertility of the land under the peculiar circumstances of Indian conditions it will be impossible to continue to extend the area of wheat crops without mixing them or alternating them with leguminous crops. With a continuance of or an increase of wheat production, a corresponding increase of pulse production may be confidently expected. The hardening of the prices of Indian pulses,

* Described in the *Veterinary Journal*, for 1885 and 1886, under the title of "Lathyrus-poisoning."

already begun in our home markets, will tend to develop the growth of these crops. The grain trade of India with Europe is the great means by which India liquidates her increasing indebtedness to this country, and consequently, when not suspended by famine prices in India, it is certain to continue until some more convenient substitute is found.

There is a general impression that rice is the common food of the native population. It is so only in Bengal, Assam, and Burma. The millets—Jowar (*Sorghum vulgare*), Bajra (*Pennisetum typhoideum*), and Ragi (*Eleusine coracana*) — elsewhere form the staple source of food-grain. With the millets are associated in this connection, lentils, pease, and gram (*Cicer arietinum*), which are of vast importance in raising the standard of the inferior millets to one capable of supporting a healthy physical condition. In addition to these foods, a large quantity of oil is necessary for the maintenance of health. The two great sources of oil are (1) the clarified butter, or "ghee," provided by the humped cow and female buffalo, and held as more or less of a luxury by the wealthier classes; and (2) the vegetable oils pressed from various species of oilseed grown for the purpose. It is well known that oil or fat is an important ingredient in the food of the Esquimaux to support the animal heat. It is not so widely known that oil is quite as essential, though for a different purpose, for the native races of the tropics. Among other possible functions, it supplies an oily secretion in the sweat necessary for the protection of the external horny layer of the skin, when exposed to strong sunlight and heat. If oil is not present naturally in the food, it would appear that the vital functions of the system are enabled to manufacture it under certain conditions, possibly by means of the degeneration of albuminoids. This is a wasteful makeshift of nature, though necessary under the circumstances, that can be avoided by a properly balanced diet.

If people are confined to such a food as ragi, which is poor in both albuminoids and oil, as is the case in some of the poorer districts of Madras, skin diseases appear to follow as a natural result.

I should like to convey to you some idea of the impression I formed of the ryot, or labouring agricultural population of India, although this is most difficult to accomplish in the case of those who are unfamiliar with the great extremes of climate, and the wonderful difference in the circumstances and environments, as compared with this country. It should also be borne in mind that the characters and practices of different races, or the inhabitants of different districts, though of the same race, differ materially. When free from the demoralising and baneful influences of famine, the ryot is usually an easy minded, contented individual who enjoys life in a simple manner and at a moderate cost as regards his every day expenses. He is, however, prodigal and extravagant to a degree in the matter of ceremonial feasts, such as marriages of members of his family or of his possibly numerous dependent relations. That he may marry his daughters respectably, he frequently plunges irrecoverably into debt. Once in the grip of the money lenders, there is little chance of escape. The interest due becomes enormous, but the *Soucar* does not press for immediate payment. He judiciously keeps a watchful eye on his chances, and quietly bleeds to the limit of his victim's endurance. Indebtedness does not appear to bear heavily upon the ryot, and his enjoyment of life seems unimpaired.

The most important operations in working the land are restricted within comparatively short periods. The soil, for example, in the unirrigated districts being indurated and baked on the surface to a condition very much like that of a macadamised road, cannot be ploughed till rain comes, and after that event the sooner the crop is planted the better, so that it may be well advanced before the moisture is again dried up.

During these seasons of urgency, nothing could exceed the devotion and attention to duty exhibited by these simple people, and, in the rice districts especially, often under trying circumstances of discomfort, if not actual danger to health. The greater part of the year is spent in semi-idleness and listlessness, which has a lowering moral influence.

There is nothing one could conceive which would be of greater universal benefit to the Indian people, largely dependent upon agriculture as they are, than some device which would supply the means of employment for the agricultural population when their presence is not required on the land. The intelligence and skill of the Indian cultivator have been enormously under-estimated.

In the matter of a knowledge of the facts and processes of nature he is infinitely superior to the rural labourer of this country; his power of observation is much keener, and his knowledge of the objects which are con-

stantly before him is not to be compared with the blank ignorance in the mind of the corresponding British workman.

After a careful study of the so-called shortsightedness of the natives, who declined, merely with the habitual sway of the head as the sole reason, the many advices which have been freely given to them for their improvement by European residents, I felt constrained to say, "Bravo, old ryot! You are not such a fool after all. They blame you for ignorant prejudice, for not adopting all sorts of suggestions for your *improvement*, but your ignorant prejudice is just what many a one who thinks himself a very wise man would be much the better for possessing." It is simply a good share of common sense associated with a knowledge of things, along with the strong instinct of self-preservation, and a highly-commendable practice of a true constitutional principle, viz., positively to decline to acknowledge that every change must be an improvement, even if it is recommended by some confident enthusiast. Nothing impressed me more strongly than the unsuitability of European agricultural practices to Indian conditions, and the fitness of the native implements and methods of working to the peculiar prevailing circumstances. The native is quite open to persuasion when he sees that an alteration or an improvement will suit his purpose; but unless his foresight assures him of it, he resolutely declines to venture into doubtful experiments. Indian agriculture, it is true, is far from perfect, but its advancement can only be brought about by improvement of current practices, not by importation of foreign methods.

One important reason why British agriculture has greatly advanced within this century without Government aid, while Indian agriculture has remained stationary, is that the agricultural classes, of the community were drawn up with the other classes through the greatly increased material wealth consequent upon the development of manufactures and the growth of the foreign trade of the country. In so far as one class cannot exist without another in a country practically self-supporting as Great Britain was before steam revolutionised our mercantile marine, and developed the foreign grain trade, one large class cannot distance the others to any very alarming degree. The good fortune of the one reflects upon the other. The enormous influx of England's wealth for many years enabled agriculture to prosper in spite of all disadvantages. This country had also the benefit of individual enterprise and a voluminous newspaper press, which was not possessed by India in the same degree or manner.

The most recent returns by J. E. O'Conor, of "Price and Wage Levels" (two items which generally tend in the same direction, though the tendency may differ in degree) "in India, 1861 to 1873, and 1874 to 1887," show, as accurately as statistics of the kind can do under the circumstances, that upon the whole, with a few notable exceptions in special articles, the tendency has been towards a decrease both in the prices of food grains and of the cost of agricultural labour. It must be admitted, when the best has been said for Indian statistics on these matters, that, after all, they only claim to be indications of the truth, not even approximations to it, because so many extreme exceptions come in, that unless these are eliminated altogether, the resulting averages become contorted and misleading.

From them we may be safe to gather, however, that no such rise in prices as occurred in this country before the bad times of recent years came upon us, took place in India. This is rather an interesting feature, when considered in connection with the steady rise in the revenue assessment on land. In 1887 (using the most recent returns), the total land assessment stood, in tens of rupees, at 23,000,000 odd, an increase of over 15 per cent in ten years. No doubt a portion of the increase was due to extension of cultivation; but it is also well known that the assessments on land which has been long under cultivation, have, as a rule, been steadily increased at every re-settlement in those parts where it is not held in perpetuity. I do not mean to imply that the assessment is too high, or that the system of fixing it is defective to a degree which would make it oppressive; on the other hand, I feel confident that the assessment is moderate, and that the method adopted in determining it brings out marvellous results considering the meagre amount of knowledge of a practical agricultural kind possessed by the officers who are employed in this branch of the Government service.

Without endeavouring to give a complete description of the procedure in land settlement, I may now with advantage very briefly note a few of the more important points for consideration involved in the Bombay settlement. This recurs, in the case of each holding, every thirty years. In other words, the ryots of Bombay correspond to Government tenants under

thirty year leases. Taking a part of the country* at some distance from an important centre of population, a maximum rate per acre is fixed, beyond which the assessment cannot be raised. With this sum as a basis, the settlement officers are instructed to make deductions, where necessary, under such heads as the following:—(*a*) Where the soil is not three feet deep; (*b*) where it is not of uniformly good quality, as containing stones or sand; (*c*) where it is steep or uneven in surface; (*d*) the position as regards railways or local markets; and (*e*) the proximity to water for irrigation purposes. The number of points for consideration, and all judged of separately, eliminate the chances of error in the final calculation, and so simplify the work that men with no special knowledge of agriculture can arrive at a wonderfully fair and uniform result after a little experience of the system.

The gradual increase in the land revenues of recent years has enabled Government to tide over its increasing difficulties in connection with European financial liabilities; but what I wish to point out is that, with a downward tendency in the price of agricultural produce, the increases of revenue from land cannot continue without pressing upon the people. True, the ryots may have a greater total return in spite of lower prices, by growing and exporting more grain, yet the possibility of their doing so individually is slight, though the aggregate result, as regards India, may appear considerable. There is no great supply of manurial material used to increase crops above the bare normal yield of the soil. The export of grain, and the prodigal and wasteful shipment of the bone manure supplies of the country, will in time, though not within the present generation, unquestionably, reduce the growing power of the soil. Although bones as manure have been neglected by the natives of India, owing to religious scruples, yet, what they omitted to accomplish for themselves in the matter of bone distribution, jackalls and and other predatory animals did for them.

Before the export of grain and bones began, there was no important drain upon the natural resources of fhe land, and it no doubt maintained very much the same power of crop-production from year to year, and from generation to generation.

One of the burning questions of the day in India is that of home rule; and though, for the moment, it has little to do with agriculture, yet sooner or later, if it progresses, it will affect the interests of the agricultural population. The ryot is the great taxpayer, and change of this kind usually brings increased taxation and increased expenditure. In dealing with the subject it is necessary to go back to the facts underlying our early occupation of the country. We took possession of India at first in our own interests, as well as in the interests of the people themselves—we have, by doing so, conferred enormous benefits upon both ourselves and them. By British capital and enterprise, combined with a stable and good Government, we have opened up the country, and have freely given to the great masses of the people the blessings of peace and security which they never knew before. These are noble objects, worthy of our powers of colonial government, and our superior European civilisation. But it is only shirking the point to deny the fact that we hold India in our own interests in the first instance, and in the interests of India in the second. We have found in India a vast field for our trade manufactures, which has added enormously to our wealth and importance as a nation. India is also the great outlet for the surplus intellect of our educated upper and middle classes. No one could conceive what would have been the result to this country of the retention at home of the men who have spent their lives in the government services of our Eastern Empire. The clamour in India for change simply means the minimising of these privileges which appear to us from length of possession or prescription to be our rights. Whatever justice there may be in our claim, there is little doubt but that Great Britain feels the benefits of such a relationship as has been described to be of too much importance to India, as well as to herself, to knowingly or willingly yield to extreme measures of change. I do not assume the position of asserting that no improvements can be worked in the present form of administration, or that no greater measure of self-government should be conferred upon the country, because it is no doubt plain to many that in both instances more or less of a change is necessary; but what I do protest against is the possibility of a small number of malcontents being accepted as the representatives of the Indian ryots, who, while they are the great tax-payers, are yet innocent of any knowledge of politics, or any burning desire to enter into the duties or responsibility

* The word "district" has to be avoided, as in India it has a special meaning, nearly corresponding to county in England. Officially, it means the area placed in charge of a collector and magistrate.

of a share in the government of the country. No increased native representation of an elective kind could ever be genuine among these people under present circumstances, and it would be a misfortune if, by agitation and false promises, the ryots were ever subjected to the demoralising influences of undergoing a political training. They are already contented and (unless at intervals of decreasing frequency) happy. From the glimpses of political life we see in this country—and, I might add, also in France and in the United States of America—we ought not to be impressed with the desirability of extending its influence.

It will be a serious calamity for Great Britain when Indian government is made a subject of party contention. It would be a hopeful sign to see a greater general interest than exists at present taken in Parliament in questions affecting India by both political parties, if that could be accomplished in a spirit of mutual forbearance.

Much of the discontent of India has been caused by the over-zealous efforts of Government to develop a high-class system of English education, without calculating the after consequences, or realising the full effects upon the individuals educated. Education as it is got in schools, is a subject over which—in all good faith and earnestness of purpose—many over-anxious individuals go, sentimentally, quite mad. A kind of vague notion takes hold of them that book-learning is all and all, and quite worthy of any sacrifice. Unfortunately, book-learning will never make a man practical, but it has every chance, when carried to extremes, of making him extremely unpractical.

In a practical world like this, the limit of useful employment for those who are poor and unpractical, however learned they may be, is soon reached, and those who are in excess of the full and necessary complement, within the limit, are left a burden upon society. The special conditions of India multiply the evils, and we are now beginning to realise the consequences of them.

As an exaggerated illustration of the rate at which education is discounted in India, in the case of many of those who have been unfortunate in securing Government positions, I may be allowed to mention the relative rates of pay given to the different classes in the Santal country. When with my excellent friend, the Rev. Alexander Campbell, at Jamtara, I found the rate of a butler's wage was ten rupees per month, while the salary of a schoolmaster was only five rupees for a similar period.

The great object for which a native youth goes through a full University curriculum, including English, is to qualify himself for an appointment under Government; but should he be unsuccessful in his attempt, he is left practically worthless for any other available employment. His education, which may be said to extend over a dozen years, has unfitted him for the occupation to which he would naturally have turned had Government not tempted him to leave the natural course of his existence for the study of books.

Another complication arises in the fact that a native who has got an English education will not work with his hands. The English official in India does not work in this fashion, and the idea seems to be that when the native is educated up to the standard of a British civilian he ought to be above the performance of anything so menial as hand labour. The consequence is that, unable to find some other congenial occupation, the average native who has been disappointed in securing a Government connection remains a burden upon his family, and an active centre of discontent. The mistake lies in Government having provided means of instruction for a much greater number than can, under existing circumstances, ever secure situations under Government, or in the various railway services and centres of commercial life. What is wanted to remedy the existing and growing evil is not so much the reduction of State education as a re-moulding of it, so that it would have a practical side of equal importance with the purely intellectual side. And, further, that encouragement should be given for the development of means of employment for the overflow of men of education, such as is secured to this country by private enterprise, in arts, commerce, and manufactures. India is unable to relieve a congested condition of this class by emigration; there is, in consequence, greater need for action in the matter. The agricultural department for India, which I sketched on a previous occasion, would be one of the most useful institutions for accomplishing this desired result as a secondary object, the improvement of the agriculture of the country being, however, its first aim. There are indications that Government is alive to the importance of some of the more urgent requirements which I took the liberty of drawing attention to in my recent publication, viz., in

the matter of appointing an agricultural chemist, in the establishment of a colt nursery (which is to be located at Ahmednagar), and in the extension of the cattle-breeding farm at Bhadgaon, in Khandesh. The two latter are practically settled, but the former, along with various other acknowledged prospective improvements, is deferred on account of financial difficulties.

One prominently important branch of agriculture which in India is capable of enormous development is the cultivation of grass land. A most creditable attempt has been made in this direction at Allahabad, but as a national necessity it is capable of great extension. India is possessed of a large number of excellent species of grasses utterly different from those of Great Britain; but in addition to grass, in the proper cultivation of it, forage-producing trees ought, in clumps and in single standards, to occupy a considerable surface area. Numerous species of fig afford shelter and shade, and their leaves are specially valuable as fodder in dry seasons or in times of famine and scarcity. Under such circumstances the green pods of *Inga dulsis* and of *Acacia* (Babul) are used with great advantage in the feeding of stock. The value of the combination of the grass forage and tree forage is, that when in seasons of excessive drought the grass is worthless, a supply of food is, nevertheless, to be had from the trees. Owing to the unsettled weather at the time when grass is ready to cut, hay-making as a rule is not at all successful. This leaves abundant scope for silage, and it would appear that it will only be a matter of a few years before the manufacture of stack silage is a general practice throughout India. One point which is in favour of the increase of grass cultivation is that, when properly carried out, it leaves a margin of profit. It is consequently not so much the money that is wanted in this case as men who are well trained in the special work.

Efforts in the direction of advancement are not altogether confined to official quarters. The London Dairy Supply Company has arranged to send out a qualified agent to try to introduce the Laval "Baby" hand-cream separator through bringing it before the people by practical demonstrations at convenient centres. Its cost will be about £14. If it can be made cheap enough to meet the native taste, there is every probability of its being taken up, enthusiastically, by certain classes. If it has success similar to the Bihiya sugar mill, or to the sewing machine among native tailors, it will quite revolutionise the manufacture of butter and ghee in India.

The question of finance "blocks the way" to many improvements which are urgent, and in no instance more injuriously than in the matters of agriculture. No subject has been more warmly contested than the altered relations of the British and Indian wheat growers, due to currency changes. A common conclusion has been arrived at, viz., that although the native has not possessed a bounty to encourage the development of trade with Europe, yet encouragement to grow wheat was not wanting from other sources, and a decided advantage has been maintained by the Indian grower over the British grower. The amount of this advantage is still a vexed question, but even more wonderful is the want of unanimity as to whether India, in common with other nations, has suffered in consequence of the divergence in value of the currency mediums (gold and silver) of England and India. It is an extremely contracted view to take of the situation to argue that because India did not suffer so much as England during recent years that she was consequently a gainer by the misfortunes that befel the foster - mother country. Why, if England had been as prosperous in trade as she was depressed, her demands for foods and other Indian products would have been greater, and more would have been realised for them.

One of the greatest losses to India, owing to the course of currency changes, is the continued straightened circumstances of the Indian Government, struggling to make ends meet in the financial statement from year to year. Hence the cheese-paring, and thereby the crippling of institutions that exist, and also the failure to establish new or extended branches of the services that are clearly demanded in virtue of recent advances. But, further, the actual sum of money lost to the Indian Government through exchange, from and including the financial year 1872-73 amounts to, in round numbers, £58,000,000—including accumulated interest and compound interest at 3 per cent., and presuming that the losses of the current year and of last year are equivalent to the loss of 1886-7—a sum which, had it not been for the loss on exchange, would have reduced the permanent debt of India from its present amount 9,265 million rupees, or (reckoning the rupee at 1s. 5d.) from £65,500,000, to the extremely moderate sum of £7,500,000.

But for the alteration of the relative values

of gold and silver, India would have been all but free of permanent debt.

Should the last published rate of annual loss by exchange—amounting to fully £4,500,000 in 1886-87—continue for the next ten years India will be loaded with an additional debt of £52,370,000, or a final total result in 1899 of £130,800,000, lost by exchange since 1872-73. Let those who assert that the altered currency relations have been a gain to India show the balance of gain over this prodigious loss.

Though this at first sight appears to be more a financial than an agricultural matter, yet the burden which falls so heavily upon the ryot is deserving of special notice. Not only has the cultivator had to bear a large share of this exceptional and altogether unproductive tax, because paid away without reaping the advantage of an equivalent, but he has been also forced to suffer the loss resulting to him from the inability, through want of funds, of Government to establish an agricultural department which could have conferred upon him all the many advantages derivable from an adaptation of the teaching of European science.

These appear to be the leading disadvantages of the currency changes from the Indian point of view. The chief loss as regards British manufactures, and one which is progressing and growing, is the transfer of Indian trade to other silver-using countries, in which we have no interest. I look upon the adoption of bi-metallism as a most probable means by which anything of national importance can be done for the flagging interests of Indian agriculture; as a means of saving the ryot from the pressure of increased taxation, and the empire from impending bankruptcy.

[At the end of the paper, Prof. Wallace explained in detail a series of lantern slides representing various native tillage implements, specimens of breeds of humped cattle and buffaloes, besides different species of plants which produce the food grains of India.]

DISCUSSION.

Sir Robert Dalyell, K.C.I.E., said he had listened to the paper with great interest, but as he had not been in India for twelve years, which was equivalent to fifty years in England, he was not in a position to criticise it, his knowledge being now quite out of date. If, however, India of to-day was anything like it was when he knew it, he thought Professor Wallace had fallen into a slight error with regard to prices, which were certainly considerably higher than they were, say, twenty-five years ago. Professor Wallace had taken 1860 as his starting point, but if he had gone back to 1850, he would have found that prices had increased very considerably, and that consequently, making allowance for the difference in prices, the land revenue assessment was really not much more than half what it was then. He thought rather an alarmist view had been taken of the prospects of the land revenue, though it was astonishing how sound were the views taken by Professor Wallace on many points, considering the short time he had spent in the country, particularly with regard to local government. Most visitors to India, members of Parliament, and others, came back with very different ideas, and proclaimed the introduction of representative institutions as the only alternative to giving up the country altogether.

Sir Henry Cunningham, K.C.I.E., said he could quite confirm the remarks of the last speaker with reference to the question of the land revenue. He had studied the revenue statistics compiled by Sir Robert Dalyell, and confirmed them on a tour of observation round the whole of India, on which he was sent by the Government, of which Sir James Caird was a member. The conclusions to which the commission came entirely bore out the fact that so far from there having been any increase in the share taken by the Government of the agricultural produce, there was a great diminution. He remembered very well the figures compiled by Sir Robert Dalyell as to the Madras Presidency; and in the North-West Provinces, again and again, not only had the Government not increased the amount of produce which by law it was entitled to take, but had considerably diminished it. In the Punjaub, when it was annexed, the Government took 10-11ths of the produce, leaving the native proprietor 1-11th, but now the Government in no case took more than about half. He congratulated the reader of the paper on the soundness of his views on local government, though he was not prepared to follow him in his remarks on bi-metallism. On one or two points he thought his paper might be calculated to mislead those unacquainted with the facts of the case, the general impression to be derived from the paper being that the financial condition of the Government, produced by the fall in exchange and other causes, had rendered a cheeseparing policy essential, and thereby the agricultural department had been crippled, and the ryot injured. That, however, was not the case. In the first place, there was no doubt that the agricultural peasant, owing perhaps to accidental and temporary causes, had certainly greatly benefited. All those who lived in India knew that the moment the exchange fell trade revived, and very often when there had been no trade going on in Calcutta, no corn coming in, there being

no market for it, a fall in the exchange had the effect that it immediately became worth while to export wheat to England, trade revived, and a period of prosperity set in. With regard to the cheeseparing policy, he was perhaps in a better position than any one else to give an opinion, having been a member of the committee which went round a year or two ago for the purpose of cheeseparing. They went into every part of the country, and examined everyone they could get hold of, and there again he might relieve the alarms of Professor Wallace by saying that, as far as he was concerned, he failed to discover this cheeseparing policy, and he might even go so far as to challenge Professor Wallace to point out any department the usefulness of which had been curtailed. Great as had been the emergencies no branch of the service had been crippled in its usefulness by financial retrenchment. With regard to the agricultural departments, the Government had, of course, to watch them with considerable attention, and it was possible that the slowness of growth might excite the surprise and annoyance of people who would like to see things done more rapidly, but if Professor Wallace inquired minutely into the great province of Bengal he would have found both there, as well as in Madras and Bombay, agricultural departments doing useful work, though no doubt greater progress might be hoped for hereafter. With regard to the character of the Indian ryot, no doubt, like other semi-barbarous people, he was very ingenious, but he laboured under an enormous disadvantage when contrasted with those possessed of scientific knowledge. A very careful examination had been made into the product of the food-producing area of India, and the general result was that the average product was ten or eleven bushels to the acre. Now the average product in England was 29 to 30, and on highly cultivated lands much more, and Lord Leicester considered that we ought to get at least one-third more from the land. That made a difference of from 17 to 20 bushels over the enormous area of India, and it was calculated that if the average yield could be brought up to that of England it would supply food for an additional population of over 400,000,000. In face of the grave alarms expressed with regard to the over-population of India, that was a very satisfactory fact, and one which he believed the agriculture of the future was destined to accomplish.

Surg.-Major INCE, M.D., said that, considering he derived entirely from India all the little worldly goods he possessed, he could not but feel very thankful to Professor Wallace for the kindly tone in which he had spoken of the ryots; they deserved our sympathy, not only as supplying so much of the wealth which our middle and upper classes derived from India, but as members of the universal human family; and they no doubt possessed many most admirable qualities. Beyond this he could not go very far in agreement with Professor Wallace, whose opportunities for observation in India had been, he was afraid, too few to allow him to speak quite so positively as he had done. It was utterly impossible, for instance, to grow grass and make hay in India under ordinary conditions, especially in those parts where there was no water. Without water you could grow almost nothing, but to grow grass, abundance of water was required, and the idea of extending the silo system, or cultivating grass to any profitable extent, might at once be dismissed. Many points had been introduced, connected not only with the social but the political condition of India, and the question of home rule had been pronounced upon. He knew there were gentlemen present who were opposed to the principles of the National Congress, and unfortunately, those who had been longest in India were generally most opposed to it, but there could be no doubt that the Government must be prepared to, he thought, give more liberty and greater facilities for self-government, which term he preferred to home rule, and it was more appropriate. There was no doubt that the desire for more self-government was the natural fruit of a wise and liberal system of education. When people were able to look intelligently around them, and understand a little of the government, and their rights and privileges, it was only natural that they should desire a greater voice in the management of their national affairs. With regard to these educated native Bengalees, Professor Wallace did not seem to have come into contact with many of them, and he was inclined to believe that the desire for self-government was much more extensive, and a much more loyal feeling than he supposed.

Mr. ROBERTSON (Principal of the Agricultural College of Madras), after speaking in high terms of the admirable illustrations which had been given, said he could not agree with Mr. Wallace in many points put forward. That gentleman had enjoyed very limited facilities for forming his opinions. In a period of four months he had travelled some 13,000 miles, and out of that time he had spent a fortnight in Ceylon, so that there were about 100 days left for India, during which he had travelled on an average 130 miles a day. Those who were familiar with India knew that travelling in the hot season was done mostly at night; and, that it was difficult to make agricultural observations from the windows of a railway carriage. The area of India was about 1,300,000 square miles, which, divided by 100, would give 13,000 square miles per day inspected by Professor Wallace, whereas when reporting for the Madras Government, he thought 10 square miles a day very good work. Besides, the time when Professor Wallace was in India was not the season when he would have the best opportunities of inspecting agricultural operations, and he did not suppose he saw 100 acres of wheat growing in all his travels. He did not think soil and dirt was purposely mixed with the wheat; the picture which had been shown of the method of threshing was quite enough

to show how impossible it was to avoid earth and gravel getting mixed with the grain. The increased consumption of Indian pulses had been referred to, and also the possibility that anthrax might in this way be introduced; and he would add that it might equally be introduced by means of Indian wheat, for in the process of threshing the excrement of the animals fell on the grain. If Indian pulses were as good as English beans and peas, and could be supplied at a much lower price, they would no doubt come more into consumption; but their production was very small as compared with wheat. Last year the agricultural statistics showed an import of about 600,000 cwt. of pulses—or pease, as they were called—against over 50,000,000 cwt. of wheat and rice. He sympathised with the ryot, whom he had known for twenty years, whilst Professor Wallace had only known him about twenty weeks, and he was quite ready to admit that he was a man of fair average common sense, but he could not admit that he was at all equal to the average English agricultural labourer. Of course the ryot had difficulties to contend with in the shape of caste prejudices, and other matters which were unknown in this country. He quite agreed with the remark that English agricultural implements were generally unsuited to India; no one of any sense would suggest that India should be cultivated according to English practices, but the general principles of agriculture were not applicable to all conditions and circumstances in England, India, or elsewhere. He was not aware that attempts had been made to introduce English practices except in some limited cases here and there. Mr. Wallace asserted that European stock have white skins, and Indian stock black skins, that the white-skinned animals suffer more from heat than those with black skins. Now, it has yet to be proved that all Indian stock have black skins. His (Mr. Robertson's) experience was decidedly that a large proportion have skins that differ but little in colour from European stock, while sheep, poultry, &c., usually have white skins. He had had half-bred English cattle that stood exposure to the hot sun in South India as well as native stock with which they were grazed. But, putting aside this question, he would ask if it was the case that stock with light-coloured skins suffered more from heat than those with black skins? Well, Mr. Wallace determines this point to his own satisfaction, he tells us that he placed his hand on the back of an animal of a native breed, and on the back of a cross-bred English animal, and he thinks that the skin of the latter was hotter than that of the former. The sheep were generally white, and the poultry nearly all had white skins, but it did not follow that they were any the less able to withstand the heat of the sun. There were many people in southern India who were nearly white, and though it was true that they did not stand the heat quite so well as others, he thought it was mainly due to their being principally employed in more sedentary occupations, and that if they were employed out of doors in the same way as the darker races, they would stand the sun as well. Professor Wallace spoke of the greater quantity of nitric acid in the air in India than in England, and he based that statement on an observation he made of twelve flashes of lightning in one minute. Experiments had been made on this point; the rainfall in Madras had been tested for two years, and it was found to be the case that the rain-water contained more nitric acid than in this country. With regard to grass, one gentleman had said that it could not be grown in India, but, as a fact, it was grown there, though not perhaps so successfully as in Europe. There were, no doubt, endless difficulties in growing grass on dry land, and the ryots as a class would not sow grass seeds. He did not suppose that in the whole of India there were thirty acres of grass—excepting that in Government hands—which had been sown. As to silage as opposed to haymaking, he thought no English farmer who could command the conditions for haymaking which existed in India would think of using a silo. He did not condemn the silo where you could not make hay, but where you had abundant sunshine, the silo was not necessary. The cream separator, which Professor Wallace would introduce into India, would, no doubt, be useful if it could be introduced, but it would be more difficult to do so than an improved plough. The latter, of good patterns, were being introduced, the great difficulty hitherto experienced being that of getting them repaired; but the smiths in some places were taking to do this, and no doubt the time would come when the improved plough would be generally adopted. Famine was due largely to the absence of water; when the land became dry the crops failed, and if they could deepen the soil, and stir it more thoroughly by means of the improved plough, great improvement would be effected by the soil taking up and holding more water. A cubic yard of soil could be stirred with an European plough at one-half the cost of doing it with an Indian plough, so-called. The fact was that India had remained stationary while other countries had progressed. On the whole he thought the subject of the paper had been generally fairly treated, considering the limited opportunities Mr. Wallace had enjoyed, and the diagrams were exceedingly life-like and valuable.

Mr. A. Rogers feared a wrong impression would be formed of the process of the Bombay land settlement if the statement in the paper were not a little further explained. Several points had been mentioned which it was said were all considered in settling the revenue, but, in fact, it would be simply impossible for a settlement officer to take all those points into consideration. One process was gone through rather mechanically, of settling what were called "classes," to settle the relative value of lands in the same locality, and when that was done the settlement officer came in and fixed the money value, according to these classes, on various considera-

tions—nearness to a railway, and so on, which had been mentioned. The operations of the settlement officers were confined to questions of that kind, and did not go into details, which it would be practically impossible for them to deal with as to the relative values of different soils. The reader of the paper seemed to think that there was a fear of the settlement being unduly raised at the end of the thirty years; but he could guarantee that that would not be the case. By law, improvements could not be taxed; dry crop land did not pay any more when turned into wet; and besides that, in order to ensure that there should be no inordinate increase, rules had been laid down that at any revision of the settlement at the end of thirty years, no increase on the Taluka should be more than one-third; on a group of villages two-thirds; or on a single individual more than 100 per cent. when prices of produce had risen, or other general reasons might render such an increase fair. It was perfectly impossible, therefore, that the great increase which seemed to be feared should take place. One speaker said the Government revenue would be equal to half the produce, but in Bombay it was nothing approaching it; the utmost would be 1-3rd. He had had a great deal to do with settlement work, and always took care to compare the money rates with the value of the produce and the quantity, and in many cases he found that the proportion taken was much nearer 1-6th or 1-7th than 1-3rd.

Mr. W. MARTIN WOOD said the term home rule had been introduced into the paper, which was entirely an English expression, seldom heard in India, though there was undoubtedly a strong desire growing up amongst the rural population to have some share in the management in their local affairs. With regard to the broader question which that introduced—the dependence of India on England—the reader of the paper had said that finance blocked the way, and this was undoubtedly correct. With all respect to Mr. Justice Cunningham, who was one of those who saw everything for the best, Professor Wallace was much nearer the truth in alluding to the impoverishment of many of the productive and industrial pursuits of the country, caused by the very serious financial deficiency; and he believed that this starvation of many departments was due, to a large extent, to the expenditure of the resources of the country beyond its own boundaries for unproductive purposes. He ventured to think there was some error in the figures Professor Wallace had given bearing on the loss by exchange; but at any rate, they brought out one of the most important factors in the condition of India—the withdrawal of such a large amount of annual produce from the country without material return. The loss by exchange was merely an illustration, and an exaggeration; but there were from £10,000,000 to £15,000,000 a-year exported from India without any material return whatever, and that fact in itself went far to explain the low industrial condition of the country, and to prevent the improvements which Professor Wallace and others so heartily desired. Unless something could be done to mitigate that drain, these lamentations as to want of progress must continue. If anyone had a right to criticise Professor Wallace it was Mr. Robertson, but he ventured to think that gentleman had been rather too severe in some of his criticisms. For his part, it was astonishing, considering the short time the Professor had spent in the country and the distance he traversed, to see how he had escaped the errors which many had fallen into, and how closely he had followed, though without imitating, Sir James Caird in many of that weighty authority's conclusions respecting Indian agriculture.

Mr. W. S. SETON-KARR said he would not follow Professor Wallace into the political questions he had raised, which he thought were better avoided on these occasions, though in the main he agreed with him, but would confine his remarks to the agricultural part of the paper. It was said that the district officers in India were not practical chemists, and that might be true; but he could produce some Settlement officers who knew as much about wet and dry land irrigation, about the curious efflorescence in the North-West Provinces called *Reh*, and all the causes which affected agriculture, as any man could do. His own remarks must be taken to apply to Bengal, because India was such a large place that very often when a man brought forward some fact as having occurred under his own eyes, he was immediately tripped up by some one who said he had lived so many years in India, and he had never seen anything of the kind in Tanjore or in Guzerat. Professor Wallace said it was a pity they did not grow hay. Well, in Bengal they did; he had grown it himself, but it was not for fodder, but to thatch the houses; and he did not think they would ever get the ryot who valued his rice land, to grow hay as we understand it. As for silage, it was a fine dream, but in Bengal would be a useless expense for many years. He had seen in one Report that silage had been introduced into Assam, about the last place in the world where it was required, as there was plenty of jungle and grass, a brief hot season, and plenty of rain. Professor Wallace said he should like to see other occupations for the ryot when he was idle. In Bengal there were two crops in the year, and the ryot had plenty to do. Perhaps in April or May he might be a little idle, before the setting in of the rainy season, but his labour began in June, and went on unintermittingly, with his early crop and his late crop, right through the winter, and, excepting for a portion of the year, he hardly knew any month when the Bengal ryot was an idle man. Of course, he did not work like an English navvy, but he did not see why he should have more burdens put on his back. He should rather take exception to the statement of Sir Henry

Cunningham that the productive power of the land could be increased indefinitely. It has been proved from the statistics in Bengal that possibly by skilful agriculture 10 or 12 per cent more might be got out of the land, but anything further was quite out of the question. The staple crop was the deep winter rice crop, and if there were a favourable rain season the streams overflowed with silt, and you had as fine a crop as there was 3,000 years ago. On the other hand, if there were no rains, no power on earth, and no manure and no skill, would produce a crop. There were some interesting reports on the wheat supply by Mr. McDougall in which, though he admitted the extreme beauty of the Indian hard wheat, he said it made the bread too brittle, and did not do well unless mixed with English flour. The main difficulty in India was over-population. In the district with which he was most familiar it was from 600 to 700 to the square mile, and with all the skill, manure, and best ploughs in the world, the land would not produce much more than it had done.

The CHAIRMAN, in proposing a vote of thanks to Professor Wallace, said he hoped the lecturer would be gratified with the capital discussion his interesting paper had evoked. He would just mention what had been done in Madras towards improving agriculture. In 1866, the late Sir William Denison, the then governor, appointed an experimental farm committee, of which Sir Robert Dalyell was a member, and he (the Chairman) was for some time honorary secretary, and that committee worked to the best of their ability for some years, until they got Mr. Robertson to come out and take charge of the farm. Their objects were to make experiments in the rotation of crops and with manures, to introduce new and better seeds, new fodder plants, and grasses, and to improve tillage by means of better implements. They also tried to improve the breeding of live stock, and he thought no efforts in these directions could be thrown away in India or in any other country. It had often been argued that the agricultural population of India was not capable of appreciating anything like scientific cultivation, and that the only way of approaching the ryot was by putting before him the simplest and most obvious improvements suited to his intelligence, and especially to his means. This was no doubt true, and it would be equally true in any country where very small parcels of land are held by peasant cultivators; but it did not hold good of the zemindars and large landed proprietors who had education and means, and had educated people under them. They could accept a more advanced agricultural teaching, and through them it would filter down to the ryots. Tillage could never be improved without better implements, and there the zemindars and the Government could step in and help the ryot by showing him at district exhibitions better implements, produce, and stock, and encouraging him to till the land better, and secure better crops. The ryot was very conservative, no doubt, but it had been proved in Madras that he was quite ready to adopt a better description of plough if it could be supplied him at a price at all within his means. When he was Commissioner for India at the Exhibition in Vienna, in 1873, he saw some Swedish ploughs there which he got sent out to India, which were sold to the ryots at twelve or fourteen rupees, and they had spread immensely, and were much appreciated. At the same exhibition at Vienna, being British juror for agricultural machinery, he noticed, in the report which he drew up for the British Commission, specimens of implements used in the remoter parts of Eastern Europe which would hardly bear comparison with the ordinary Indian plough, such as had been shown to-night. That was only sixteen years ago, but now in those localities in Europe they had excellent iron ploughs and harrows, and even reaping and threshing machines. It might be hoped, therefore, that by instituting district exhibitions on a modest scale, the ryot might be induced, in a short time, to look into the question of tillage, and that gradually cultivation would improve, and also the system of manuring.

The vote of thanks having been carried,

Professor WALLACE, in reply, said he knew he had raised points which would be certain to elicit differences of opinion, and on the whole, he thought he had been let off pretty easily. He did not pretend that the paper was at all what it might have been had he had more experience of the country. Of course he bowed at once to the opinion of those gentlemen who had had a large experience of revenue matters, but he should like to point out that, although he admitted the accuracy of their statements, if a longer time were taken, the tendency would not be quite the same. He had dealt with the period of the last twenty years, during which the currency changes had occurred, and during that time there had been a downward tendency in prices, though no doubt there was a rise previously; and he thought that what had been said in that view rather confirmed this views on the currency question. He was brough up amongst agricultural people, and had a faint idea of what they knew, and he must say that the Indian ryot was infinitely better acquainted with everything he met with in the field than the English labourer. You could not ask a ryot the name of any grass but he could tell you, whereas an English labourer would not recognise one. The ryot only wanted scientific education to make him one of the finest cultivators in the world. It was no doubt a hard thing for Mr. Robertson to be told that a man went out to India and saw things which others had not noticed who had had them under their eyes for twenty years, and he had referred to a veterinary surgeon who had criticised his work. That gentleman took five columns in the leading Bombay paper to do so, but was unable to show one trace in the English

language of a statement of the fact that the black skins of the cattle of India had been noticed by an Englishman; and on the other side he had the highest scientific authority in England for saying that the fact was hitherto unknown. He would challenge Mr. Robertson to prove—it need not be settled to-night—that one per cent. of the cattle in India had white skins; and it was proved beyond a doubt that those which had were liable to a disease of the skin in a hot sun; anyone who knew anything of cattle could pick them out, even at a distance. He had seen more cattle than perhaps any officer in India, as he paid special attention to them, and visited all the most important centres where they were bred. It was suggested that he had travelled at a great rate, and that he could not have done much else. He certainly did a great deal, but he went a long distance at a time, and then settled down for a time to do his work; and, thanks to the Indian civilians by whom he was always received with the greatest courtesy, he had every opportunity afforded him of investigating the matters in which he was interested. With regard to grass, he must protest against some of the opinions he had heard expressed. They were simply expressions of local experience, and in discussing Indian questions local opinions must not be held to be generally applicable. That was the weak point of Mr. Robertson's speech; he had been speaking about matters which had not come under his special knowledge, because wheat was hardly grown in Madras. Grass had been cultivated on dry land, and it was a very simple operation when you knew how to do it. He rode over a thousand acres of grass cultivated on dry land, which never was irrigated. A bank was made round the field, and when the rain fell the water was conserved for a time, so that the grass had a good start before the dry season came on. Grass was abundant in most places, but there you could not make hay, and it was there he had hopes of seeing silage introduced. Mr. Robertson said he did not know that English ploughs had been tried in India, and later on he advocated their adoption. The fact was there was not an agricultural department which had not an English plough lying about somewhere because it had not succeeded. He saw ploughs of various descriptions in Madras, and with one or two exceptions they had proved a complete failure, for the simple reason that it was ruin to turn up the Indian soil in the condition in which it was worked. You wanted to conserve on the surface the dry powdery mould, and to keep the wet clay underneath. The Indian plough did that, but the English plough buried the mould which we were striving, even in this country, to keep on the top. He quite admitted that the knowledge of the district officers was very extensive, but it was not that scientific, absolutely accurate knowledge which would do Indian agriculture good. For this purpose it was not sufficient to have the knowledge picked up by busy men engaged in other work. They wanted some one who had studied agriculture in this country to go out and study it there, and devote himself entirely to it. It was a subject quite big enough for any man, and that was the only way to avoid the mistakes which had been fallen into in trying to improve Indian agriculture; and it must be admitted that, on the whole, the efforts had not met with the success which was expected. It was partly for want of money, for he had heard it stated in Madras by a pretty good authority, that if the Agricultural Department did not do much good, it could not do much harm.

FOURTEENTH ORDINARY MEETING.

Wednesday, March 13, 1889; PROFESSOR SIR HENRY ROSCOE, M.P., LL.D., F.R.S., in the chair.

The following candidates were proposed for election as members of the Society:—

Blair, Thomas, Wingerworth Ironworks, near Chesterfield.
Jones, Chapman, 36, Bristol-road, Edgbaston, Birmingham.
Mann, John Randall, New Barn Cottage, Osborne, Isle of Wight.
Rigby, John, 9, Charlotte-street, Bedford-square, W.C.
Simmons, L. Owen, Wolvesey, Winchester.

The following candidates were balloted for and duly elected members of the Society:—

Bernard, Sir Charles Edward, K.C.S.I., 44, Bramham-gardens, South Kensington, S.W., and India-office, S.W.
Collenette, Adolphus, 11, Commercial-arcade, Guernsey.
Flower, Thomas James Moss, 1, Passage-street, Tower-hill, Bristol.
Horncastle, Henry, Chobham, near Woking, Surrey.
Richards, Edward Harrinson, Lagos, West Africa, and St. George's Club, Hanover-square, W.
Richardson, William, Florence-villa, 121, Pershore-road, Edgbaston, Birmingham.
Stevens, Joseph Wallace, Belph, Whitwell, near Chesterfield.
Thurston, Frederick, Hastings-street, Luton, Beds.

The paper read was—

ALUMINIUM AND ITS MANUFACTURE BY THE DEVILLE-CASTNER PROCESS.

By WILLIAM ANDERSON, M.Inst.C.E.

Aluminium was shown to be a distinct substance in 1754, by Marggraff. It may be ranked among the noble metals, because

it does not tarnish, even when exposed to damp and very impure atmospheres, and, until lately, it was almost a precious metal, the price ranging as high as 60s. per pound; indeed, even now, absolutely pure aluminium is scarcely to be obtained, the metal used in the arts being contaminated with from 2 to 5 per cent. of iron, silicon, and other substances. The chemical symbol of aluminium is Al, its atomic weight is 27·4. Aluminium is very widely diffused over the earth, its silicate forms the chief constituent of clays; and enters into the composition of a vast number of minerals, especially of felspars; its fluoride, united with that of sodium, forms cryolite; a ferruginous hydrate is known as bauxite, and forms probably the most convenient ore from which to extract the metal.

The method now generally adopted in preparing aluminium was discovered early in this century by the eminent French chemist, Henri Saint-Claire Deville, and consists in reducing the double chloride of aluminium and sodium, ($2NaCl\ Al^2\ Cl$) by means of metallic sodium at a high temperature. The manufacture, therefore, resolves itself naturally into two parallel processes, the one comprising the preparation of the double chloride, and the other the production of metallic sodium. As sodium to the extent of nearly three times the weight of aluminium is required in the reduction of the latter metal, it will be seen that the cheapness and abundance of the aluminium depends very much on the cost of the sodium, and the quantity in which it can be produced. Till quite recently, the price of sodium was as high as 5s. a pound, and the process of manufacture was so difficult, and even dangerous, that very large quantities could not be obtained. The improvements effected by Mr. Hamilton Y. Castner, in the manufacture of sodium, by which it can be made in any quantity, without the slightest risk, at about 1s. per pound, has rendered it possible to produce aluminium, of about 98 per cent. purity, which can be sold profitably at 20s. per pound.

The object of this paper is to describe the process of manufacture adopted by the Aluminium Co., at the works, which have just been started, at Oldbury, near Bimingham.

We will first take the manufacture of the double chloride of aluminium and sodium. The raw material is hydrate of alumina $Al^2O^3 +$ water, which is the only oxide of aluminium. It can be prepared in a variety of ways, and from various materials, such as common alum, which is the double sulphate of aluminium and potassium, $AlK\,(SO^4)\,12H^2O$, from bauxite, which, as already stated, is a ferruginous hydrate, and from other substances, the price being about £13 per ton, when it is sufficiently pure for the purpose.

The hydrate of alumina, in a finely-divided state, is mixed on a suitable floor, with lamp-black, charcoal, and common salt, moistened with water, the mass is thrown into a pug mill, and after being thoroughly mixed and incorparated, is forced through dies, constructed exactly as in a drain-pipe machine, the issuing cylinders of the compound being cut off by wires into pieces about three inches long, which are carried to the tops of the chloride furnaces, and spread out there to dry thoroughly.

The next process is to expose the mixture of hydrate of alumina, carbon, and salt to a high temperature, in presence of chlorine gas, in order to obtain the vapour of the double chloride, which is distilled over, and condensed in the form of a deliquescent, light yellow substance, of very pungent odour. This operation is performed in regenerative furnaces, constructed very like banks of ordinary earthenware gas retorts. The gas from the producers plays round groups of five retorts, set in ovens, in which their temperature is raised to a bright red heat, the exact intensity of which is a matter of much importance, and requires an experienced eye to regulate.

The retorts are connected at their mouths—that is, their opening ends—by means of earthenware pipes to gasholders, containing chlorine gas, special means being taken to regulate the pressure of the gas, and the rate at which it is allowed to flow. The opposite ends of the retorts are fitted with pipes, which convey the fumes of double chloride to cast-iron condensers, and thence to brick chests or boxes, the outsides or ends of which are closed by means of wooden doors. Convenient openings are arranged for clearing out the passages, because the double chloride condenses very quickly; the greater portion of it liquifies and trickles down into the brick chambers, while a portion sublimes, and comes over in the form of a yellow powder. The brick chambers are emptied from time to time, and the contents packed away in air-tight wooden chests, a precaution rendered necessary on account of the deliquescent properties of the substance. The reaction which takes place is as follows:—

$$2Al_2\,O_3 + 3C_2 + 4Na\,Cl + 6Cl_2$$
$$= 2(Al_2\,Cl_6\,2Na\,Cl) + 6CO.$$

That is, two molecules of alumina, three molecules of carbon four molecules of salt and six molecules of chlorine, give two molecules of double chloride and six molecules of carbonic oxide.

The chlorine gas used in the retorts is manufactured on an enormous scale, being prepared in the usual way, by the action of hydrochloric acid on manganese dioxide, at a moderately high temperature. One molecule of the manganese dioxide combining with four molecules of hydrochloric acid, produces one molecule of manganous chloride, two molecules of water, and one molecule of gaseous chlorine.

$$Mn\ O_2 + 4\ HCl$$
$$= Mn\ Cl_2 + 2\ H_2O + Cl_2.$$

The manganous chloride is soluble, and forms the "spent still liquor," which is reconverted into manganese dioxide, by Weldon's method, that is by first neutralising all free hydrochloric acid, by means of powdered limestone, and then adding milk of lime to the neutral solution, when manganous oxide and calcic chloride are formed.

$$Mn\,Cl_2 + CaO = MnO + Ca\,Cl_2$$

By exposing the manganous oxide to a strong current of air, it takes up another atom of oxygen, and becomes again $Mn\ O_2$, or manganese dioxide.

The chlorine plant forms a very imposing part of the factory. The hydrochloric acid is conveyed by a 2-inch gutta-percha pipe a distance of some 700 feet across the canal, from Messrs. Chance Brothers' Alkali Works; it is received into six large stone storage tanks, each capable of containing 10 tons, and from these it is run, as it is wanted, into two large stone stills, made up of huge slabs of sandstone, cramped together in an ingenious manner by iron bolts and cast-iron angle saddles, the joints being made by means of solid india-rubber cord. In these stills the manganese dioxide and the acid are mixed together, and, being warmed by injected steam to the proper temperature, the chlorine gas is, at first, given off rapidly, and with effervescence; the rate gradually decreases, and at length the disengagement of gas ceases altogether. The chlorine is carried off by means of lead and earthenware pipes to four large lead-lined gas-holders, capable of containing several thousand cubic feet of gas, and from them it is led away to the double chloride retorts, various ingenious devices having been introduced for indicating the pressure of the gas, and measuring the quantity passed into each retort. Chlorine, besides being valuable, is a very disagreeable gas when it gets out of its proper place, hence great care and method are required in manipulating it.

The "spent still liquor," the solution of manganous chloride, is run into a large neutralising well, 20 feet diameter, and 20 feet deep, built of stone, and fitted with agitators; it is there neutralised by intimate mixture with powdered limestone, and is allowed to settle, after having been pumped up to a system of tanks elevated above the oxidising tower, during which process, iron and some other impurities are carried down. The clear solution, which has a pinkish colour, is then run into the oxidising tower, which is a wrought-iron cylinder standing on end, about 12 feet diameter, and 30 feet high, where it is warmed by injected steam; milk of lime is added, and the whole violently agitated by a powerful current of air, pumped in at the bottom of the tower by an 80 h.p. horizontal engine, driving a large double acting air pump. In two or three hours, the manganous oxide has absorbed as much oxygen from the air current as it had at first given up to the hydrogen of the hydrochloric acid, and thus reverts to its original state.

The contents of the tower, now a thick black turbid liquid, are run into a second system of settling tanks, five in number, erected below the level of the tower. The tanks are each 18 feet square by 7 feet deep, and are used alternately for settling the charges as they are withdrawn from the tower. The recovered manganese dioxide settles out, leaving a clear solution of chloride of calcium, which is drawn off by overflow pipes, and the recovery process is then complete, the manganese mud being thus used over and over again, and re-recovered, suffering but an inconsiderable amount of loss in the process.

We next come to the manufacture of sodium. Previous to the year 1886 sodium was produced by reducing it from the hydrate or carbonate of soda by heating it to a very high temperature, with an excess of carbon, great care being taken to avoid fusion of the mass, to which end lime was added. Fusion was prejudicial to the process, because, when fused, the carbon separated from the alkali, and only a small return was obtained, hence the temperature had to be carried sufficiently high for the alkalis to be volatilised, because only in that form could the soda compounds come into sufficiently intimate contact with the carbon

for its combination with the oxygen of the alkali to take place, and set the metallic sodium free. The high temperature required caused great wear and tear of the iron retorts in which the process had to be carried on, and dangerous explosions were not uncommon; the practical effect being that the production of sodium was very limited in quantity, and the price, as already stated, ranged as high as 5s. per pound.

Mr. Castner, a chemical engineer, of New York, became possessed of the idea that, if suitable means were discovered, it would be possible to reduce the sodium and potassium compounds at a much lower temperature by bringing the carbon into intimate contact with the alkalis in a molten condition. If six molecules of the hydrated oxide of sodium commonly called caustic soda be added to one molecule of carbon, it will yield, when heated to a high temperatute, two molecules of carbonate of soda, three molecules of hydrogen, and one molecule of sodium—

$$6NaHO + C_2 = 2Na_2CO_3 + 3H_2 + Na_2$$

and the reduction will take place in an atmosphere of hydrogen, provided that a sufficiently intimate contact can be secured between the carbon and the alkali. Mr. Castner's process to attain this end, arrived at after a couple of years of patient experiment, is partly mechanical and partly chemical. He prepares an artificial carbide of iron by coking an intimate mixture of finely-divided iron and pitch, or other hydrocarbon, the result being a heavy metalliferous coke, which, when ground fine and mixed with caustic soda in the fused condition, blends intimately with it, and causes the reduction of the soda at a temperature very much below that hitherto found possible, namely, below that of melting silver, which has been estimated to be about 1,000° C. The chemical reaction during reduction cannot be confidently defined, but it probably is somewhat according to the following formula :—

$$4NaHO + FeC_2 = Na_2CO_3 + Fe + 2H_2 + CO + Na_2.$$

That is to say, four molecules of caustic soda and one molecule of the carbide of iron, as above defined, produce, in the liquid form, one molecule of carbonate of soda and one atom of iron; while two molecules of hydrogen, one molecule of carbonic oxide, and one molecule of sodium escape in the gaseous state. The hydrogen and the carbonic oxide ignite, and burn with a brilliant flame coloured by the characteristic sodium hue, while the sodium distils and condenses into suitable vessels. The reduction thus takes place in an abundant atmosphere of hydrogen and carbonic oxide, which effectually preserves the sodium from oxidation till it can be safely deposited in mineral oil.

The apparatus for preparing the sodium is sufficiently simple. The caustic soda is received in drums from the neighbouring alkali works of Messrs. Chance Brothers. The finely-divided iron is mixed with melted pitch in iron pots set in a suitable stove, and the mixture of pitch and iron is then calcined into coke in large iron retorts set in an ordinary furnace.

The metalliferous coke is ground into a fine powder by means of ordinary edge runners, and is ready for charging into the sodium retorts, which are of specially ingenious construction, and deserve a detailed description. Each furnace is heated by gas, applied on the regenerative principle, and contains five cast steel crucibles, or pots of an egg-shaped form, arranged with their long axes vertical. The upper part of the egg is formed into the head or cover, much like the artificial Easter eggs which contain sweets, but it is fitted with a vertical pipe, which passes up through the top of the furnace, and forms the passage by which a portion of the charge is introduced, and it also has a lateral branch connected to the condenser, which consists of a small cast-iron vessel, of peculiar form, arranged so as to allow the fluid sodium to trickle out, to let the hydrogen and carbonic oxide gases escape, and to afford facilities for cleaning the passage, so as to prevent it from becoming choked. The form of this condenser is of some importance if the best results are to be obtained. The whole of the head above described is secured immoveably in the upper part of the furnace, and is protected by the oven setting from extreme heat; it can, however, be readily removed if desired. The lower part of each retort rests on the top of a vertical hydraulic lift, which is worked by a moderate water pressure, provided by a special duplex pump, and it is this pressure which, with the interposition of some luting, forms the joint between the head of the retort and its lower portion. The upper part of the lift, or platform, is so arranged that when the retort resting on it is in its place, the aperture in the bottom of the furnace is completely closed. When the lift is lowered, the bottom half of the crucible sinks to the floor level, and a two-wheeled iron hand-truck of special construction is wheeled up, and,

catching hold of the crucible by two projections on its sides provided for the purpose, lifts it off the hydraulic ram, and, by the aid of two men, transports it to the "dumping" pits, on the edge of which it is turned on its side, the liquid carbonate of soda and finely-divided iron, which forms the residue, are turned out, and the inside is scraped clean from the opposite side of the pit, under the protection of iron shields. When clean inside and out, the crucible is again lifted by the truck, and carried back to the furnace, receiving a portion of the fresh charge on its way. It is then again placed on its ram and lifted to its place, having still retained a good red heat. It takes two minutes only to remove and clear a crucible; from six to eight minutes performs the same office for the set of five, and the whole cycle of operations, including the distilling of the sodium, requires one hour and fifteen minutes. The five crucibles yield 500 lbs. of sodium per twenty-four hours, so that the battery of four furnaces is competent to yield 2,000 lbs., or nearly one ton of sodium per day.

The only portions of this plant liable to exceptional wear are the bottom halves of the crucibles, the durability of which is fouud to depend very much on the soundness of the cast steel of which they are made, because any pores or hollows are rapidly searched out by the furnace flames. The average duration of each crucible at present is about 750 lbs. of sodium, or 125 charges. The carbonate of soda removed from the retorts is returned to the alkali makers, and is again converted into caustic soda, fit for further use.

The six pounds of sodium, the produce of each charge, is allowed to trickle from the condensers into small iron pots, in which, when cool enough, it is covered with mineral oil, and then transported to the sodium store, where it is melted in large pots, which are heated by an oil bath, and cast into ingots of convenient form for the subsequent operations. The strong affinity of sodium for oxygen is well known, hence it is best kept covered by an oil, such as mineral oil, which does not contain oxygen in its composition; and the greatest care has to be taken to protect it from water, because water is decomposed with so much energy by sodium, that the heat caused by the clashing together of the atoms of sodium and the oxygen of the water is sufficient to ignite the liberated hydrogen. Hence the apparent paradox that, to make the sodium store fireproof, it is necessary to make it waterproof also, and, at the same time, to avoid naked lights, which may chance to set the vapour from the oil on fire.

We have now got the two ingredients required for the production of aluminium, namely, the double chloride of aluminium and sodium, and metallic sodium. The double chloride is broken into small pieces and mixed with cryolite (the native fluoride of aluminium and sodium, $6Na\ F.\ Al^2\ F^6$), and with metallic sodium, cut into thin slices by an ordinary tobacco-cutting machine. The mixture is tightly enclosed in a revolving wooden box, in which it gets thoroughly mixed. This part of the process is somewhat trying, on account of the hydrochloric acid gas given off by the double chloride, which slowly decomposes when exposed to the air. When the ingredients are sufficiently mixed, they are turned out on to the hearth of a regenerative reverberatory furnace, over which the mixing cylinder is placed. The hearth is made to slope towards a lateral opening, which is closed during the process of reduction by clay, supported by iron plates and keys. There are two furnaces, a small one capable of producing 60 lbs. of aluminium per charge, and a large one which yields 140 lbs. The charge introduced into the furnace melts quickly, and a reaction, represented by the following formula, takes place—

$$2(NaCl)\ Al_2Cl_6 + 3Na_2 = 8NaCl + Al_2.$$

That is to say, one molecule of the double chloride and three molecules of sodium yield eight molecules of common salt, and one molecule of aluminium. The process of reduction lasts about three hours. The melted slag, which consists chiefly of common salt, and the cryolite, which merely served as a flux, is drawn off by breaking the clay stopping of the hearth opening, from above downwards, and, finally, the lower tapping hole is broken through, and a silvery stream of metallic aluminium runs out, and is received into cast-iron moulds. The reducing operation requires considerable skill, and great attention to the temperature of the furnace, which has to be varied during the continuance of the reaction.

The large furnace is competent to produce 840 lbs. of aluminium per day of twenty-four hours, and the small one, 360 lbs.

The first portion of metal which runs out, and which forms rather more than three-fourths of the charge, is of the greatest purity; the remainder, which has to be scraped off the hearth, or which gets entangled in the slag, and has to be subsequently separated out, contains a larger proportion of foreign

substances. The cause of the difficulty in obtaining the separation of the metal from its slag, consists in the very low specific gravity of aluminium.

The metal is now taken to the casting house, arranged like an ordinary brass foundry, is re-melted in plumbago crucibles, and cast into ingots, plates, or bars for subsequent sale or manufacture.

It is evidently impossible, in a paper of this kind, to enter into all the details of manufacture, although these details are of the highest importance in obtaining commercially valuable results. Day by day, as the manufacture progresses, improvements are made which enhance either the economy of production or increase the purity of the sodium or aluminium produced. Such improvements in details cannot very well be made public till their value is thoroughly ascertained, and the protection of the Patent-law obtained when considered necessary.

The following Table gives the quantities of the several ingredients employed to make one ton of aluminium:—

Metallic sodium	6,300 lbs.
Double chloride	22,400 ,,
Cryolite	8,000 ,,
Coal	8 tons.

To produce 6,300 lbs. of sodium is required:—

Caustic soda	44,000 lbs.
Carbide made from pitch, 12,000 lbs. .... Iron turnings, 1,000 lbs.	7,000 ,,
Crucible castings	$2\frac{1}{2}$ tons.
Coal	75 ,,

For the production of 22,400 lbs. double chloride is required:—

Common salt	8,000 lbs.
Alumina hydrate........	11,000 ,,
Chlorine gas	15,000 ,,
Coal	180 tons.

For the production of 15,000 lbs. of chlorine gas is required:—

Hydrochloric acid	180,000 lbs.
Limestone dust	15,000 ,,
Lime	30,000 ,,
Loss of manganese	1,000 ,,

The works are constructed to produce $1\frac{1}{2}$ tons of aluminium per week; the quantities of the ingredients consumed are, consequently, half as much again as the figures given in the Table, it is easy to see, therefore, that the factory must be on a very large scale, and the brief account of the process which I have given indicates also how complicated the manufacture is, and how much care and skill are necessary to conduct it successfully, if pure aluminium is to be made. The great enemies of the metal are iron and silicon, especially the former. When once it gets in, it is impossible to get it out again by any commercially practicable means, hence every precaution has to be taken to ensure the purity of the materials, to which end a well appointed laboratory, presided over by Mr. Baker, a very able chemist, is kept in active operation.

The works are situated on the Birmingham and Dudley canal in the town of Oldbury, immediately opposite the chemical works of Messrs. Chance Bros., who, as already stated, supply the hydrochloric acid by means of a two-inch gutta-percha pipe carried across the canal, and conducted right into the chlorine plant. They also send the caustic soda in the most convenient form for working, and at small expense for packing, and offer the like facilities for the return of the spent carbonate of soda.

A dock, which forms a branch of the canal, enters the works and accommodates the boats, from which coal and other materials are lifted by a steam-crane. The gas producers, eight in number, are arranged on each side of the dock, and have their coal lifted at once on to their feeding-stages by the steam-crane, and from these producers the gas flues are led to supply the chloride, the sodium, and the reducing furnaces. The works were designed by Mr. Castner, and they were built under his personal supervision in a very short time, and are now under his direct management, assisted by his able lieutenant, Mr. W. H. Cullen, who has been and still is the resident engineer in charge. It is difficult to speak too highly of the skill and energy which has been displayed, and the steady perseverance which has been exhibited in overcoming the difficulties which presented themselves as the manufacture was gradually brought to its present state of perfection.

Aluminium is endowed with several remarkable properties. It is the lightest of the metals which possess considerable tenacity and hardness. A given volume of aluminium is only a little more than $2\frac{1}{2}$ times (2·65) the weight of an equal bulk of water, whereas iron is $7\frac{3}{4}$ times, copper nearly 9 times, gold $19\frac{1}{2}$ times, and platinum $21\frac{1}{2}$ times as heavy as water.

The metal has a bright silvery lustre, it is capable of taking a very high polish, and of retaining its brilliancy and colour under conditions which would rapidly tarnish silver, because it does not oxidise from exposure to either dry or damp air, and is unaffected by that great enemy of silver, sulphuretted hydrogen, or other sulphur compounds present in our London fogs, either at ordinary temperatures, or even at a red heat, witness the ingots on the table, which are exactly in the same condition as they came out of the moulds. At ordinary temperatures it is not affected by either strong or diluted nitric acid; weak sulphuric acid has no action on it, neither have sulphuretted hydrogen or sulphide of ammonium, which explains the reason why it does not tarnish, even in very impure atmospheres. The two strips of polished metal before you have been for eight months in a City office, but show no indication of tarnishing. Water has no effect on pure aluminium under ordinary conditions, but if it be made the oxygen pole of a galvanic battery, it is readily converted into alumina, forming a copious white precipitate. The vegetable acids, such as acetic and tartaric, have no effect, hence aluminium is admirably fitted for making into cooking utensils, coffee-pots, teapots, &c., its extreme lightness being also an advantage for this purpose. It is not acted upon by the hydrates of potassium and sodium in a state of fusion, but solutions of these alkalis in water dissolve it readily, forming aluminates of potassium and sodium, with evolution of hydrogen. Of this property the silversmith takes advantage in producing very beautiful frosted effects, by plunging the polished metal for an instant into a weak solution of caustic soda, washing in a large quantity of water, and then digesting in strong nitric acid. Its powers of conducting heat are high in the scale, being about two-thirds that of copper; its specific heat is ·22, only lithium, sodium, and magnesium being above it. Its electrical conductivity is eight times higher than that of iron, and about equal to that of silver; its elasticity and tenacity are equal that of silver, and have been determined by Mr. W. H. Barlow at about 12 tons per square inch, but weight for weight, its tenacity would be the same as high-class steel, or 36 tons per square inch, that is to say, bars of equal weight would carry the same loads. Experiments on very fine wire have given the same results. It is very malleable and ductile, when proper attention is paid to annealing during the process of working, a precaution common to the manipulation of most metals. Aluminium of about 97 per cent. to 98 per cent. purity may be rolled into thin sheets, and may be beaten into foil, as thin as any that can be produced from silver and gold. It can be drawn into very fine wire, such as the specimen which I exhibit, of only 1-10ths millimetre diameter, and ought to supersede silver in the manufacture of metallic braid and tissues, because it will never tarnish as silver does. It can be stamped or spun into hollow ware, but there is, as yet, some difficulty in soldering it; at any rate, the process of performing the operation is known to very few people.

Aluminium forms alloys with most metals. Iron is always more or less associated with it, but it seems doubtful whether it be a true alloy, or wholly or in part a mixture, like the carbon contained in cast iron and in steel. Silicon is also invariably found associated, more or less, with the metal. Aluminium added to molten iron and steel lowers their melting points, and, consequently, increases the fluidity of the metal, and causes it to run easily into moulds and set there, without entrapping air and other gases, and forming blow-holes and similar imperfections. It is, in consequence, used to the extent of about $\frac{1}{2}$ per cent. and less by some steel founders, and seems to render the production of sound steel castings more certain and easy. Admiral Kolokolzoff, the director of the great gun factory near St. Petersburg, informs me that he uses ferro-aluminium, an alloy with iron, containing 10 per cent. of aluminum, and adds it to the crucibles of melted steel, about ten minutes before pouring, in the proportion of one pound of the alloy to 80 pounds of steel, which gives one part in 800 of pure aluminium, and the result is that he gets the largest steel castings, such as I have myself seen, completely free from air-bubbles, and with very excellent mechanical properties.

One of the most remarkable applications of the property which aluminium possesses of lowering the melting point of metals has been made by Mr. Nordenfelt, in the production of castings of pure iron, that is to say, iron free from any sensible quantity of carbon or manganese. Pure iron melts at about the same temperature as platinum, that is, about 1700° C. yet, even then, the molten mass is not liquid enough to be run into moulds, but the addition of from $\frac{1}{2000}$ to $\frac{1}{700}$ part, by weight, of aluminium lowers the melting point to such an extent that it becomes fluid enough to run into the most minute and intricate forms. Mr. Nordenfelt has given the name of mitis (flexible ductile),

to his metal, and I am indebted to Mr. Faustman, one of the inventors of the process, for the interesting collection of mitis castings, which is here before you. I would especially draw your attention to this wire brush; it is a solid casting; the back and iron bristles form one mass, and yet, you can see, that the bristles may be bent about just like the sofest iron wire.

The process of manufacture is as follows:—Wrought iron is placed in crucibles, which are put into a liquid-fuel air-furnace of peculiar and ingenious construction. In a furnace for six crucibles, for example, they are arranged on an elongated hearth in pairs, cross partition walls being so built as to cause the flame to embrace each crucible thoroughly. In the roof of the furnace are openings, covered by movable, brick-lined plates, or doors, through which the crucibles can be got at. The flame playing over the hearth is conveyed by a short flue, fitted with a damper, to the chimney. Under the hearth is another flue, communicating with the furnace, and also leading to the chimney, and fitted with a damper. By manipulating the two dampers the flame may be directed either under or over the hearth at pleasure. The furnace proper is at the end of the hearth farthest from the chimney, and consists of a peculiarly constructed apparatus, whereby the cheap residues resulting from the distillation of kerosene, or the heavy oils obtained from gas works, can be burned with the ordinary chimney draught, and a most intense heat produced. The pair of crucibles next the furnace are the most highly heated, the metal in them melts first, and, as soon as the crucibles are removed for pouring, the remaining four are moved up near the flame, and two freshly charged ones put in at the end nearest the chimney, by which means most of the heat produced by the combustion of the fuel is utilised. As soon as the iron is fairly melted, but not overheated, aluminium is added, when the charge instantly becomes quite fluid, and fit for pouring, the lowering of the melting point having had the same effect as superheating the metal.

The mitis castings possess all the properties of the best forged iron, the tensile strength ranging as high as 27 tons per square inch, with an elongation of 20 per cent. The metal can be worked and welded just like wrought iron, and in fact cannot be distinguished from it, except that it is perfectly homogenous and free from stratification.

When aluminium is used in such small quantities, it is best to make a preliminary rich alloy with iron, say one containing from 10 per cent. to 25 per cent. of aluminium, and then to add so much of the alloy to the charge in the crucibles as will give the desired proportion of the more costly metal. This is the more necessary on account of the extreme lightness of aluminium, which makes it reluctant to mix with a metal three times its specific weight.

Aluminium alloys readily with copper in all proportions, and constitutes the metal known as aluminium bronze. The usual proportion ranges from 2½ to 10 per cent. of aluminium, and it is probable that the bronzes resulting form true alloys or solutions, because the addition of the lighter metal causes a marked increase of temperature of the molten mass, indicating the existence of chemical reaction, and the bronzes may be melted frequently without changing the relative proportion of the constituent metals. The tenacity and rigidity of the copper is much enhanced; 10 per cent. alloys having sustained as much as 45 tons per square inch, with an ultimate extension of 25 per cent. It must be remembered, however, that, to obtain the best results, absolute purity, or, at any rate, fixity of composition, both in the copper and aluminium, must be insured; failing that, very discordant and disappointing results will be arrived at. The aluminium alloys of copper, up to 10 per cent., can be forged, and rolled hot, and worked as readily as copper, proper precautions with respect to annealing being observed. The colour of the aluminium bronzes approaches very nearly that of gold; the metal takes a high polish, and is less liable to tarnish than ordinary bronzes, or than copper itself.

Aluminium forms alloys with most other metals, but they possess no practical value at present, and, therefore, need not be described.

DISCUSSION.

The CHAIRMAN said that no doubt many were apt to imagine, from the very great progress which had recently been made in organic chemistry—for instance, in the chemistry of colouring matters—that the subjects connected with the inorganic part of science might be exhausted, and that nothing new or true, except that which was known, could come out of inorganic chemistry; but the paper just read, to which all had listened with so much pleasure, had shown that in this particular branch of chemistry — in the metallurgy of the new metal, aluminium—much might yet be done.

They often wondered what their grandfathers would think of travelling from Manchester to London in 4¼ hours, but he ventured to think that Sir Humphry Davy's feelings would have received a shock of a similar character if he had seen a ton of sodium in one mass; for in 1808 Sir Humphry described fully in the *Philosophical Transactions* how, by means of the galvanic battery, he was able to obtain in small granules a new "metalloid substance." To see a ton of this, and to hear that it was now being made in England at the rate of a ton a day, would have astonished him quite as much as our rapid travelling would have done. Mr. Anderson had explained so clearly and well all the operations, complicated as they were, of the mode of manufacturing this beautiful metal, that it was not necessary to travel over the same ground; but having had a little to do with the manufacture he might say that he looked with the greatest interest upon its future. The fact that large masses of aluminium were produced in one operation, in chemical purity, was sufficient to show that the manufacture was a reality, and an important reality. Its application could scarcely be measured at the present moment.

Professor Roberts-Austen, F.R.S., said there could be only one impression as to the value and interest of the paper read on what was a perfectly marvellous metal. He was not indisposed to admit aluminium to the rank of a noble metal—certainly it was a precious metal. The most interesting fact brought out was the possibility of replacing silicon in metals for the purpose of obtaining sound casting. This alone opened up a future for aluminium which it was impossible to restrict. He should like to know whether in the piece of aluminium referred to in the paper the elongation had been determined, as it seemed to have stretched considerably before it broke. Having had the privilege of seeing the works of the company, he could bear testimony to the admirable way in which they were arranged.

Mr. E. Riley said he had gone into this question many years ago, when Sir Lowthian Bell brought out his process, and he had some experience of the so-called alloys of aluminium, having had numerous samples submitted to him. He wished to ask whether the Aluminium Company had any process by which the aluminium could be got from clay. With regard to the result of the alloys, he thought that, practically, the alloy of copper had proved very satisfactory, but when they came to analyse it, no aluminium was found, except, perhaps, a mere trace. Some mitis castings were submitted to him a few years ago by Mr. Nordenfeldt, but he found no aluminium in them, and so it was in the so-called alloys. He had also had several samples from America. There was nothing more easy to find than aluminium, but it might be there were several things which could be confounded with it. As regarded the action of aluminium on metals, his view was that it took away the oxygen, and made the casting more solid. It was important to the Aluminium Company to know whether any of the processes put forward really reduced alumina or not. It was not an easy matter to find small quantities of aluminium. He had had samples submitted to him which were said to contain 2½ per cent., but he could only find a small trace. He believed that aluminium would be a very valuable adjunct in making steel castings, and it was now being used. He had seen samples of cast-iron in which it had been used, and found the castings exceedingly good, besides showing a considerable amount of strength.

Mr. Jeans bore testimony to the admirable way in which the company's works were conducted, and considered they reflected great credit on the inventor. There was only one other system which had all at once been brought so near perfection by its inventor, viz., the Bessemer process. Having come into contact with people who were likely to use the metal, he thought the general impression was that it would prove a valuable adjunct to the various forms in which iron and steel were manufactured. It was said that it would be an important element in the production of steel castings; but he was afraid, from the limited quantity of steel castings produced in this country, that it would not be largely used for that purpose for some time to come, though in the production of mitis castings and the like it might be employed on a larger scale. Taking the production of pig-iron in the United Kingdom as about 7,500,000 tons a year, he should be disposed to say that rather more than 2,000,000 tons were employed in the production of Bessemer steel, 1,000,000 tons in the Siemens process, and 2,000,000 tons in the production of manufactured iron, leaving rather over 2,000,000 tons for castings and other purposes. The technical literature of this country, the Continent, and the United States for some time past, had teemed with references to the subject, and experiments had been made on a large scale, which indicated that, for castings of every description, this metal was especially valuable. For some time it had been a disputed point how far aluminium was an important element in the production of steel. Professor Faraday undertook researches into the subject, in connection with Wootz steel, but his conclusions were disputed by eminent chemists, who went over the same ground; and if his memory served him accurately, Faraday considered the good properties of Wootz steel due to the fact that there was a small percentage of aluminium in it. There could be no question, from what they had seen that night, that there was a great future for the new metal in connection with the metallurgy of iron and steel; and the effect of the paper would be to throw a new light on the subject, and to inform the outside public of a matter which was of high scientific and commercial importance. He thought the time would

come when those who used aluminium for alloying purposes would prefer to have a metal in the purest condition in which it could be produced, in order that they might infuse into the casting such a proportion of aluminium as they might deem to be essential for certain specific purposes. In that way the field in the future would belong to the process which could produce the purest aluminium.

Mr. ALEXANDER SIEMENS was afraid he occupied the rather invidious position of finding fault with this very excellent process, which gave plenty of opportunities of allowing impurities to get into the aluminium. This fact was admitted in the paper. He had been asked by the inventor of a rival process to describe it, which might be done in a very few words. Mr. Grabau produced a fluoride of aluminium by certain means, and it was heated until it began to evaporate; when this temperature was attained, a suitable quantity of sodium was melted and poured into the vessel, which was lined with cryolite and cooled by water; and the heated fluoride of aluminium, in the form of powder, was thrown upon the melted sodium. Very violent reaction took place, and the heat generated by the reaction was great enough to melt the aluminium as well as the bye-product. As soon as the reaction was complete, the whole molten mass could be poured out in suitable forms, the aluminium settled at the bottom and the cryolite at the top. To obtain the fluoride of aluminium, Mr. Grabau used the cryolite, which he procured by the final reaction by putting the powdered cryolite into a solution of sulphate of aluminium. The reaction which took place between the sulphate of aluminium and the cryolite gave the aluminium fluoride. The solution was afterwards evaporated, and the residue was washed with water, which took out the sulphate of sodium, and left the aluminium fluoride ready to be reduced. The advantages of this process were that all the materials were treated at a comparatively low temperature. The vessel in which the aluminium fluoride was heated, as well as the vessel in which the reaction took place, was lined with cryolite, so that there was no danger of impurities being imported into the aluminium which was the result of the process. The low temperature was very much easier managed than the high temperatures of which Mr. Anderson had spoken.

The CHAIRMAN asked what temperature was necessary?

Mr. SIEMENS replied about 900° (Celsius), just above a dull red. The process of course required the action of sodium, and the inventor was engaged in experimenting upon a new process to prepare this, but as the necessary patents had not yet been taken, he was not at liberty to describe it in detail. At a short distance from Hanover the factory was at work producing aluminium on a commercial scale, though it was not on the magnificent scale of Mr. Castner's, but the process was extremely simple, and the extremely clever way in which the bye-products were used promised exceedingly well for the process.

Mr. W. BOBY said it appeared from the Tables that 263 lbs. of coal were used to produce 1 lb. of aluminium; and this, to his mind, seemed a very formidable figure. He was himself connected with a rival process for manufacturing aluminium, which was in practical work, by the use of the electric furnace. This process did not produce pure aluminium; but one of the great and important uses of aluminium was an alloy. If you got a pure aluminium, it was an extremely light metal, and it was very difficult to alloy it with iron. In the process of Eugene and Alfred Cowles, of America, the aluminium was produced in the furnace, and it was alloyed with iron, and came out in the proportion of 12 or 16 per cent. of aluminium to the entire mass of the product. The aluminium in the alloy may be considered pure, as we know the other constituents. It was reduced from a hard white clay known as bauxite. The interior of the furnace was 5 ft. long and 2 ft. deep; they had a dynamo, which gave a current at 60 volts of 5,000 ampères, and it was conveyed through the furnace by means of carbon electrodes; the charge of bauxite and broken iron was put into the furnace, which was luted with charcoal to resist the heat, the current was turned in, and in $1\frac{1}{2}$ hours they tapped the furnace and got out the charge of alloy. In the meantime the bauxite had become reduced from the intense heat in the furnace. There was a certain admixture of carbon in the charge, which formed a resistance to the current, and enabled it to diffuse heat through the charge. About 200 lbs. of aluminium were produced per day. In answer to the Chairman's question as to the per-centage of the silicon which the alloy of iron contains, he could not tell the exact per-centage, but he knew it was not a large one. In the copper alloy, in making 10 per cent. bronze, the per-centage was about ·5.

Mr. OLIVER J. WILLIAMS asked whether Mr. Anderson knew anything of Brin's aluminium process, which he understood produced aluminium alloy from clay at a very small cost.

Mr. ANDERSON, in reply, said the first question was as to the extension; he believed the elongation was 16 per cent. In reply to Mr. Riley, he might say that wrought-iron had been cast into large ingots, and the Germans had a cast-wrought iron, but it was new to him to hear that small and delicate castings, such as those exhibited, had been made without the use of aluminium. He did not think it could be done. Bauxite was a species of clay; and they had to pick out a material which had the greatest purity. If you could get it at a reasonable price, it was better to use a pure material than one which was impure, and have to get out the impurities

afterwards. In steel a fractional per-centage of carbon made a wide difference in the quality. He was not surprised, therefore, to find that aluminium would produce wonderful effects in the quality of the casting, and yet be scarcely distinguishable in the product. He was sorry to hear from Mr. Jeans that aluminium was not likely to be used very extensively in steel castings, and thought he was mistaken in this respect.

Mr. JEANS said what he meant to say was that the quantity of steel castings made in this country up to the present time was so small, that the quantity of aluminium to be used would be comparatively small, at any rate until the production of castings had extended.

Mr. ANDERSON said the production of steel castings was increasing immensely every day. Aluminium would be used for the following reason, that when one made a bad steel casting it was a desperate job to get rid of it. It was very important to be sure that the castings made were sound, and when aluminium could be obtained pure it would come very much into use. It was no use making impure aluminium. It was quite possible, with a little extra expense, to get aluminium containing only one per cent. of impurity. French aluminium had had the pre-eminence in this respect up to the present, but the purity of the French material had not exceeded 98 per cent. If aluminium could be got at 99 per cent. of purity, or even a little above this, it would be an invaluable material for the manufacture of fine wire for making into braid, as it did not tarnish. The process referred to by Mr. Siemens was a very interesting one, and the only objection to it was the use of cryolite. The Aluminium Company were doing their best to get rid of the use of cryolite.

Mr. SIEMENS said the cryolite was a bye-product of the raw product; it was made from the sulphate of aluminium.

Mr. ANDERSON thought that any process which would produce the metal on a large scale and cheaply would be a great advantage. He was not aware that any aluminium was made of a greater purity than 98 per cent., or at a lower price than 40s. per lb. His paper had nothing to do with the electrical process for making aluminium alloy. With regard to Brin's process, all he could say was that he had seen cast-iron smeared over with clay and water, and a metal came out which was different to that which went in, but whether the metal had any aluminium in it he could not say.

On the motion of the CHAIRMAN, a hearty vote of thanks was accorded to Mr. Anderson, and the meeting adjourned.

The following is a list of the lantern-slides exhibited by Mr. Anderson, in illustration of his paper:—

1. General view looking down the chloride plant. Gas-producers at the lower end. Six furnaces on each side. The platform above supports the large lead mains, conducting the chlorine the whole length of the building. Attached to this gas-main, and opposite each retort, are the valves used to regulate and measure the amount of chlorine passed in a given time to each retort. Underneath the main floor are the gas flues, smoke flues, reversing valves, &c.

2. View showing one of the chloride furnaces and the pipe connections to each retort for introducing the chlorine. In the rear of the view are the large trucks containing the mixture, in the form of balls, with which the retorts are charged to produce the chloride. The regenerators connected with each furnace are below the floor level, each furnace in reality being 20 ft. high, 25 ft. wide, and 10 ft. deep.

3. Exterior view. One of the large chimneys, 20 ft. diameter at the base and 180 ft. high. Oxidizing tower-top system of settling tanks of the chlorine plant. Four gasometers for the chlorine. Storage tanks for acid, &c.

4. Larger view of the same.

5. View looking north on the chlorine plant, and the two large chlorine stills.

6. Same view looking south.

7. General view of the sodium furnaces. As shown there are 10 on each side, they extend 12 ft. below the floor level, the regenerators, which are not shown in the picture, being at the back of each furnace. Gas is used in heating. The flues for same, connected by valves with each furnace, being below the floor.

8. Sodium furnace at work. Cleaning out the condensers, taking small pots of distilled sodium to the casting shop, &c.

9. Same showing the crucibles about to be placed on the hydraulic lifts, &c.

10. View of one ton of sodium as manufactured at the works by the Castner process; each bar is about 3 ft. long, $1\frac{1}{2}$ in. thick, and 5 in. wide. This pile, weighing a ton, is 7 ft. high, 6 ft. long, and 3 ft. deep.

11. Aluminium furnace. About to tap for metal mould, as shown in view ready to receive the molten aluminium as it flows from the furnace. A large sample was placed on the table just as taken from this mould. The apparatus above the furnace is for mixing and charging. The furnace is heated by gas, the flues, &c., being below the floor.

12. Canal arm, located between the sodium and chloride works. Steam crane for elevating the coal to the elevated tramway, connected by rail with the entire system of gas producers..

13. Staff of the works.

The following specimens were exhibited by Mr. Castner:—Glass jars of alumina, of caustic soda, of double chloride of aluminium and sodium, of metallic

sodium; 109·63 lbs. of aluminium, representing one run as it came from the furnace; 336 lbs. of aluminium in large and small pigs; 35·46 lbs. of aluminium in one bar; 128 lbs. of 10 per cent. aluminium bronze in large and small pigs; 155·60 lbs. of 10 per cent. aluminium steel in large and small pigs; samples of aluminium sheet, foil, and wire of different gauges, one as fine as 1-10th of a millimetre; mitis castings.

Messrs. Percy Edwards and Co., of Piccadilly, exhibited the following objects of worked aluminium:—Two gold-mounted Danish vases; two pierced gold mounts on Malacca canes; one gold-mounted flask; one heart match-box; two cigarette cases; three match-boxes; two stick mounts; one cigarette box, gold mounted; one jug, silver-gilt mounts; one beaker, silver-gilt mounts; one paper-knife, gold mounted; one fluted cigarette case, gold mounted.

Miscellaneous.

SILK CULTURE IN CALIFORNIA.

The biennial report of the State Board of Silk Culture in California states that during the year ending June 30th, 1888, raw silk to the value of 12,000,000 of dollars was imported through San Francisco from Japan, a fact showing the importance of fostering the industry in California. About 80,000 silkworms were raised and distributed gratis throughout the State by the Board during the year. The subject of silkworm rearing has of late received some attention, particularly in the southern part of the State near San Diego. One proprietor states that he has prepared ten acres of land to be devoted to that industry, whilst others write to the Board that they have made several successful experiments, and have decided to devote their time and money to sericulture.

A report by Mr. Joseph Neumann, on a wild native silkworm of California, has recently been submitted to Congress by the Commissioner of Agriculture. Mr. Neumann asks that the appropriation of 2,500 dollars, made last year to enable him to study that insect, be increased to 25,000 dollars, in order to establish temporary observatory stations wherever a good plant on which the worm feeds exists in quantities. He predicts that, "by continuing the study it will not be many years before this discovery of mine of the native silkworm will be one of the greatest blessings ever conferred upon the people of the civilised world!"

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings at Eight o'clock:—

MARCH 20.—"Objects and Methods of the Society of Arts' Motor Trials." By Prof. A. B. W. KENNEDY, F.R.S. The DUKE of ABERCORN, C.B., Chairman of Council, will preside. (The medals will be presented by the Chairman.)

MARCH 27.—Discussion on Professor Kennedy's paper.

APRIL 3.—"Fruit Growing for Profit in the Open-air in England." By W. PAUL, F.L.S.

APRIL 10.—"The Sanitary Functions of County Councils." By SIR DOUGLAS GALTON, K.C.B.

Papers for which no dates have as yet been fixed:—

"Automatic Selling Machines." By J. G. LORRAIN.

"Secondary Batteries." By W. H. PREECE, F.R.S.

"The Use of Spirit as an Agent in Prime Movers." By A. F. YARROW.

FOREIGN AND COLONIAL SECTION.

Tuesday evenings, at Eight o'clock:—

MARCH 26.—"Borneo." By ROBERT PRITCHETT. SIR RUTHERFORD ALCOCK, K.C.B., will preside.

APRIL 2.—"The Argentine Republic." By F. K. SMYTHIES.

APPLIED ART SECTION.

Tuesday evenings, at Eight o'clock:—

MARCH 19.—"The Art of the Jeweller." By CARLO GIULIANO. SIR GEORGE BIRDWOOD, K.C.I.E., C.S.I., will preside.

APRIL 9.--

MAY 14.—"Venetian Glass." By DR. SALVIATI.

INDIAN SECTION.

Friday evenings, at Eight o'clock:—

MARCH 29.—"The Progress of the Railways and Trade of India." By SIR JULAND DANVERS, K.C.S.I. SIR GEORGE BRUCE, P.Inst.C.E., will preside.

MAY 3.—"The Karun as a Trade Route." By MAJOR-GENERAL SIR R. MURDOCH SMITH, K.C.M.G. SIR LEPEL GRIFFIN, K.C.S.I., wil preside.

MAY 24.—"Indian Wheats." By JOHN McDOUGALL.

CANTOR LECTURES.

Courses of Cantor Lectures will be delivered on Monday evenings at Eight o'clock:—

WALTER CRANE, "The Decoration and Illustration of Books." Three Lectures.

LECTURE III.—MARCH 18.—Of book illustration and ideas of decoration from the 16th to the 19th centuries—Decline of inventive and applied design—Injurious effects of Renaissance traditions—Use of copperplate—Inharmonious combination of with type—Examples—Later designers and illustrators—Hogarth—Stothard—Flaxman—Examples from their works—William Blake—The Book of Job—Bewick—Revival of wood engraving as applied to illustrative art—Calvert and other Illustrators—Turner—Steel vignettes—Book illustrators of 40 years ago—W. J. Linton—Effect of the pre-Raphaelite movement—Rosetti as a book illustrator—Modern gift-books—Children's books—Development of—Japanese printed books—Influence of—American development of wood engraving, and American ideas of design and page decoration—Vedder's Rubaiyat of Omar Khayyam—Influence of the photograph—General remarks, and conclusion.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, MARCH 18...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. Walter Crane, "The Decoration and Illustration of Books." (Lecture III.)

Medical, 11, Chandos-street, W., 8½ p.m.

Asiatic, 22, Albemarle-street, W., 4 p.m.

Victoria Institute, 7, Adelphi-terrace, W.C., 8 p.m. Rev. J. M. Mello, "The Dawn of Metallurgy among Primitive Races."

London Institution, Finsbury-circus, E.C., 5 p.m. Prof. W. Boyd Dawkins, "Our Early British Ancestors."

TUESDAY, MARCH 19...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Applied Art Section.) Mr. Carlo Giuliano, "The Art of the Jeweller."

Royal Institution, Albemarle-street, W., 3 p.m. Dr. G. J. Romanes, "Before and After Darwin." II. "Evolution." (Lecture IX.)

Civil Engineers, 25, Great George-street, S.W., 8 p.m. 1. Adjourned discussion on Mr. F. J. Waring's paper, "Indian Railways; the Broad and the Narrow Gauge Systems Contrasted." 2. Mr. C. E. Emery, "The District Distribution of Steam in the United States."

Statistical, School of Mines, Jermyn-street, S.W. 7¾ p.m.

Pathological, 53, Berners-street, Oxford-street, W., 8½ p.m.

Zoological, 11, Hanover-square, W., 8½ p.m. 1. Mr. A. H. Cooke, "On the Generic Position of the Physas of Australia." 2. Mr. G. A. Boulenger, "On some Lizards in the Zoological Museum of Halle." 3. Prof. W. N. Parker, "On the occasional persistence of the Left Posterior Cardinal Vein in the Frog, with remarks on the Homologies of the Veins in the Dipnoi."

WEDNESDAY, MARCH 20...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Prof. A. B. W. Kennedy, "Objects and Methods of the Society of Arts' Motor Trials."

Meteorological, 25, Great George-street, S.W., 7 p.m. 1. Address by Dr. W. Marcet (President), "The Sun; its Heat and Light." Illustrated by experiments. 2. Exhibition of Actinometers and Solar Radiation Apparatus.

Geological, Burlington-house, W., 8 p.m. 1. Sir. J. W. Dawson, "Supplementary Note to a paper on the Rocks of the Atlantic Coast of Canada." 2. Messrs. A. J. Jukes-Browne and W. Hill, "The Occurrence of Colloid Silica in the Lower Chalk of Berkshire and Wiltshire." 3. Prof. H. G. Seeley, "Note on the Pelvis of *Ornithopsis*." 4. Mr. R. N. Worth, "The Elvans and Volcanic Rocks of Dartmoor."

Royal Society of Literature, 21, Delahay-street, S.W., 1 p.m.

Archæological Association, 32, Sackville-street, W., 8 p.m.

Civil and Mechanical Engineers, 7, Westminster-chambers, S.W., 7 p.m. Mr. Frank Telford, "The Newmarket Waterworks."

THURSDAY, MARCH 21...Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

Linnean, Burlington-house, W., 8 p.m. 1. Mr. W. B. Hemsley, "The Botanical Collections from the Christmas Island." 2. Mr. R. Allen Rolfe, "The Sexual Forms of Catasetum, with special reference to the researches of Darwin and others." 3. Prof. P. MacOwan, "New Cape Plants."

Chemical, Burlington-house, W., 8 p.m. 1. Election of Fellows. 2. Mr. W. Ramsay, "The Molecular Weights of Metals." 3. Mr. N. Collie, "Some Compounds of Tribenzyl-Phosphine Oxide."

London Institution, Finsbury-circus, E.C., 6 p.m. Colonel Gouraud, "The Phonograph."

Royal Institution, Albemarle-street, W., 3 p.m. Prof. J. H. Middleton, "Houses and their Decoration from the Classical to the Mediæval Period." (Lecture I.)

Telegraph Engineers and Electricians, 25, Great George-street, S.W., 8 p.m.

Historical, 11, Chandos-street, W., 8½ p.m.

Numismatic, 4, St. Martin's-place, W.C., 7 p.m.

FRIDAY, MARCH 22....United Service Institute, Whitehall-yard, 3 p.m. Colonel F. W. Haddan, "The Home Defence Bill as affecting the Volunteers."

Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting, 9 p.m. Mr. E. Muybridge, "The Science of Animal Locomotion in its relation to Design in Art, illustrated by the Zooproxiscope."

Civil Engineers, 25, Great George-street, S.W., 7 p.m. (Students' Meeting.) Mr. H. B. Ransom, "The Cyclical Velocity Fluctuations of Steam and other Engines."

Quekett Microscopical Club, University College, W.C., 8 p.m.

Clinical, 53, Berners-street, W., 8½ p.m.

SATURDAY, MARCH 23...Royal Institution, Albemarle-street, W., 3 p.m. Lord Rayleigh, "Experimental Optics." (Lecture V.)

Physical, Science Schools, South Kensington, S.W., 3 p.m. 1. Prof. J. V. Jones, "The Use of Lissajoue's Figures in the Maintenance of Uniform Rotation; and on the direct determination of the vibration period of a reed or a tuning-fork by means of a Morse receiver." 2. Prof. R. Threlfall and Mr. A. Pollock, "The Clark Cell as a Source of Standard Currents." 3. Prof. R. Threlfall, "The Maintenance of High Specific Resistances."

Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m.

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FRIDAY, MARCH 22, 1889.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CANTOR LECTURES.

The third and last lecture of the course on "The Decoration and Illustration of Books," was delivered on Monday evening, 18th inst., by Mr. Walter Crane. The lecturer dealt with book illustration, and the ideas of decoration from 16th to the 19th centuries.

On the motion of the Chairman, a cordial vote of thanks was voted to the lecturer for his interesting course of lectures, and for the important series of illustrations which he showed in the lantern.

The lectures will be printed in the *Journal* during the summer recess.

THE ALBERT MEDAL.

The Council will proceed to consider the award of the Albert Medal for 1889 early in May next, and they therefore invite members of the Society to forward to the Secretary, on or before the 13th of April, the names of such men of high distinction as they may think worthy of this honour. This medal was struck to reward "distinguished merit for promoting Arts, Manufactures, or Commerce," and has been awarded as follows ;—

In 1864, to Sir Rowland Hill, K.C.B., F.R.S.

In 1865, to His Imperial Majesty, Napoleon III.

In 1866, to Michael Faraday, D.C.L., F.R.S.

In 1867, to Mr. (afterwards Sir) W. Fothergill Cooke and Professor (afterwards Sir) Charles Wheatstone, F.R.S.

In 1868, to Mr. (afterwards Sir) Joseph Whitworth, LL.D., F.R.S.

In 1869, to Baron Justus von Liebig, Associate of the Institute of France, For. Memb. R.S., Chevalier of the Legion of Honour, &c.

In 1870, to Vicomte Ferdinand de Lesseps, Member of the Institute of France, Hon. G.C.S.I.

In 1871, to Mr. (afterwards Sir) Henry Cole, K.C.B.

In 1872, to Mr. (now Sir) Henry Bessemer, F.R.S.

In 1873, to Michel Eugène Chevreul, For. Memb. R.S., Member of the Institute of France.

In 1874, to Mr. (afterwards Sir) C. W. Siemens, D.C.L., F.R.S.

In 1875, to Michael Chevalier.

In 1876, to Sir George B. Airy, K.C.B., F.R.S., Astronomer Royal.

In 1877, to Jean Baptiste Dumas, For. Memb. R.S. Member of the Institute of France.

In 1878, to Sir Wm. G. Armstrong (now Lord Armstrong), C.B., D.C.L., F.R.S.

In 1879, to Sir William Thomson, LL.D., D.C.L., F.R.S.

In 1880, to James Prescott Joule, LL.D., D.C.L., F.R.S.

In 1881, to August Wilhelm Hofmann, M.D., LL.D., F.R.S., Professor of Chemistry in the University of Berlin.

In 1882, to Louis Pasteur, Member of the Institute of France, For. Memb. R.S.

In 1883, to Sir John Dalton Hooker, K.C.S.I., C.B., M.D., D.C.L., LL.D., F.R.S.

In 1884, to Captain James Buchanan Eads.

In 1885, to Mr. (now Sir) Henry Doulton.

In 1886, to Mr. Samuel Cunliffe Lister.

Iu 1887, to Her Majesty the Queen.

In 1888, to Professor Hermann Louis Helmholtz.

A full list of the services for which the medals were awarded were given in the last number of the *Journal*.

Proceedings of the Society.

APPLIED ART SECTION.

Tuesday, March 19, 1889: Sir George Birdwood, K.C.I.E., C.S.I., M.D., in the chair.

The paper read was—

THE ART OF THE JEWELLER.

By Carlo Giuliano.

In the present day, our idea of the goldsmith's art is limited to the working upon gold and silver. Our modern goldsmiths would not condescend to work with less costly materials,

but during the Middle Ages, and even at the time of the Renaissance, when the precious metals were not so abundant, the goldsmiths worked equally on copper and other metals. I therefore include in my description, under the title of goldsmiths' work, not only statuettes, bas-reliefs, vessels and jewels of gold and silver, but also shrines, reliquaries, and domestic utensils in copper, chased and gilt, and enriched with precious stones and enamels; the pewters of Briot, so wonderfully finished, and, in short, all objects of metal work which in their time belonged to the goldsmith's art.

One ought not to write the history of an art without access to the monuments it has produced; but this rule cannot be adhered to in giving the history of the goldsmith's art in remote periods. The richness of the material has occasioned the loss of many artistic treasures, and only a few pieces have been saved from falling a prey to the ignorant cupidity, the necessity, and the repeated disorders of so long a course of centuries, while fashion, that goddess of change, whose destructive worship belongs to every age, has contributed even more than these combined causes to the destruction of the finest specimens of the goldsmith's art.

In 888, Count Eudes, who had just been proclaimed King of France, presented to the Abbey of St. Germain des Prés a magnificent shrine, covered with plates of gold and precious stones, as a thank-offering to Heaven for his having successfully repelled the attacks of the ferocious Normans. In this shrine were deposited the relics of St. Germain, to whose intercession the Parisians attributed their deliverance. This monument had therefore every claim to respect, but, nevertheless, in 1408, the Abbot William, desiring to have a new shrine in the taste of his own time, consigned the undertaking to three celebrated goldsmiths, whose work, however beautiful, could never replace the former votive offering of King Eudes. Not satisfied with this first act of vandalism, this same innovating abbot melted down a very rich altar frontal that one of his predecessors had given to the abbey in 1236.

The 13th century, whose works were thus destroyed by the abbot, had furnished him with a precedent for destruction. In the reign of St. Louis, the Shrine of St. Genevieve, executed by St. Eloy, had been melted and remodelled. The men of the 16th century followed in the steps of the Abbot of St. Germain des Prés; and the tomb of St. Martin which had been enclosed, by order of Louis XI., with a silver grating of exquisite workmanship, as a testimony of the monarch's gratitude to the saint for the death of Charles the Rash, was melted down by command of Francis II., in 1522.

Thus when we see successive centuries of the Middle Ages apparently vying with each other in destroying the most venerable monuments, from no other motive than the love of novelty, we must cease to accuse as the only destroyers of the goldsmith's art the Protestants of the 16th century (who were blinded by religious fanaticism), and Louis XIV. and the Republicans of 1792, who were impelled by the necessity of providing for the defence of their country.

Whatever may have been the causes of their destruction, it is, unfortunately, too true that we possess scarcely any productions of the goldsmith's art of the first centuries of the Middle Ages, and those of a later date than the 10th century, of which but a small number have escaped, are scattered abroad. The consequence is, that after having visited all the collections of Europe, and the treasures of its principal churches, we find ourselves reduced, while tracing even an imperfect sketch of the history of the goldsmith's art, to generalities obtained from obscure texts and imperfect descriptions.

The goldsmith's art was much esteemed by the ancients, as may be easily gathered from their writings, as well as from the specimens that have descended to us. The triumph of the Christian religion under Constantine gave a new impetus to the art. We learn from the "Liber pontificalis," of Anastasius Bibliothecarius, that Constantine, at the instigation of St. Sylvester, before removing the seat of empire to the east, presented the churches of Rome with most magnificent gifts. These were crosses of gold, weighing 800 pounds, patens of gold of large dimensions, chalices of gold and silver, cruets for the wine of the offertory, lamps and lustres of different forms, enriched with the figures of animals, baptismal fonts, altar frontals, censers, and even statues of gold and silver.

The popes who succeeded St. Sylvester continued to enrich the churches of Rome with precious gifts of the goldsmith's work, as long as they were not prevented from so doing by the troubles and wars that agitated Italy. Pope Symmachus was the one who, above all others after St. Sylvester, gave orders for the most costly pieces of workmanship. Accord-

ing to the calculation that D'Agincourt has been patient enough to make from the "Liber pontificalis" of Anastatius, they amounted in weight to 130 pounds of gold and 700 pounds of silver.

Constantine had invited to Constantinople the most skilful artists, who flourished there, and it was in this city that the arts which minister to luxury made the most rapid progress. A taste for the works of the goldsmith became a general passion, and the art was no longer restricted to ecclesiastical use. The palaces of the great rivalled the churches in magnificence, these sumptuous residences were adorned with prodigious quantities of vessels of gold and silver, and the women displayed in their jewels an unprecedented luxury.

It was not only at Constantinople and Rome that the goldsmith's art then flourished. Gaul, notwithstanding the invasion of the Franks, had preserved the habits of Gallo-Roman luxury and civilisation, and the first churches built in that country by the preachers of Christianity were soon enriched with vessels of gold and silver.

There remains but little goldsmith's work of the first centuries of the Middle Ages. The only pieces handed down to us are three or four vases of silver, preserved in the Museum Christianum of the Library of the Vatican, which must have served the purpose of cruets; a toilet casket in chased silver, discovered at at Rome upon the Esquiline Mount in 1693.

The destruction of the Roman Empire by Odoacer in 476, the invasion of the Goths, the wars of Belisarius and Narses, the establishment of the Lombards, and the disturbances which were actually breaking out during their dominion in Italy, left that country few intervals of repose in the course of the 5th, 6th, 7th, and 8th centuries. Yet although among the industrial arts the goldsmith's may appear above all others to need times of tranquility for its development, it still did not cease to be cultivated, even by the barbarians.

The only specimens of that period which have reached us proceed in fact from the gifts of Theodolinda, Queen of the Lombards, to the Basilica of Monza, where they are still preserved. They consist of a rich box enclosing a selection from the gospels, the cover of an evangelarium ornamented with coloured stone, and the celebrated iron crown used at the coronation of the kings of Italy. This crown derives its name from the circle of iron incrusted in the interior, and is asserted to have been forged out of one of the nails of the true cross. It is composed of a kind of jointed collar in gold of from two and three-fourths to three inches wide, and loaded with sapphires, emeralds, rubies, and other precious stones, uncut, interspersed with flowers of gold. Apart from its antiquity, it possesses no other merit than the richness of the materials of which it is formed, and does not manifest any great artistic talent in the Lombard or Italian goldsmiths of the end of the 6th century. The reputation of these artists rested chiefly upon the crown of Agilulph, which was enriched with fifteen figures of gold—Christ, between two angels, and the twelve apostles.

Unfortunately, this magnificent jewel, which was thought worthy of being carried to Paris in 1799, after the conquest of Italy, was stolen in 1804 from the cabinet of medals in the Imperial Library, and was melted by the receiver of the theft. It ought also to be mentioned that the jewels of Monza were restored, and even in part re-made, in the 16th century, by Antelletto Bracciaforte, a celebrated goldsmith of that time, which renders it probable that the golden figures of the crown of Agilulph may have been the workmanship of Antellotto, rather than of the Lombard goldsmiths.

France, on her part, continued at the end of the 6th century to cultivate successfully the goldsmith's art, and Limoges appears to have been the principal centre of this industry. It was in this time that Abbon flourished, a goldsmith and mint-master, with whom was placed the young Eloy, who rose from a simple artisan to be the most remarkable man of his century, and whose virtues were rewarded by canonisation. The apprentice soon excelled his master, and his fame caused him to be summoned to the Court of Clotaire II., for whom he made two thrones of gold, enriched with precious stones, from a model made by the king himself, who had not been able to find a workman sufficiently skilful to execute it. The talents and probity of St. Eloy also gained him the affection of Dagobert I., who entrusted him with important works. St. Ouen, the biographer of St. Eloy, and an anonymous monkish historian of St. Denis, have left us an enumeration of his works of art. The principal of these are a large cross of gold enriched with precious stones, made for the Basilica of St. Denis; the mausoleum of that holy apostle, the marble roof of which was covered with gold and precious stones; the shrine of St. Genevieve; that of St. Germain,

and, above all, the shrine of gold of surprising workmanship, which he made to contain the relics of St. Martin, Bishop of Tours.

St. Eloy, having become treasurer and mint-master to Dagobert, was, in 640, elevated to the see of Noyon. It is easy to suppose that when a minister and high ecclesiastical dignitary, the holy prelate would give up exercising personally the art to which he owed his elevation. It was doubtless this which induced him to found the monastery of Solignac, near Limoges, in which he assembled monks skilled in all the arts, who undertook to perpetuate his instructions, and to practice the various branches of artistic industry then principally applied to the production of utensils for ecclesiastical use. Thillo, known under the name of St. Theau, a pupil of St. Eloy, lived sometime in the monastery of Solignac, for the purpose, doubtless, of directing the young monks intended for the profession of goldsmiths.

The example set by St. Eloy was followed, moreover, in after ages by princes as well as bishops; a large number of monasteries were founded with the august mission of cultivating sciences, letters, and arts, a mission nobly fulfilled, for the monasteries were their only homes during times of suffering and darkness, in the midst of wars and invasions which threatened the very existence of arts and letters.

Thus when Charlemagne wished to restore the cultivation of the arts in the vast empire he had subjected to his sway, he found in the goldsmith's department artists ready to carry out his views. The churches were abundantly provided with vessels of gold and silver, while princes and bishops rivalled each other in the magnificence of their gifts to the basilicas, restored and embellished by the orders of the powerful Emperor. Charlemagne's will, transmitted to us by Eginhard, contains curious evidence of the immense riches possessed by this prince in works of the goldsmith's art. Among other objects, we must notice three tables of silver and one of gold, of considerable size and weight. On the first was traced the plan of the city of Constantinople, upon the second a view of Rome; the third, very superior to the others in the beauty of its workmanship, was convex, and composed of three zones containing a description of the whole universe, figured with skill and delicacy. Thus science and art had united their efforts in the execution of these monuments.

A considerable number of the finest specimens of the goldsmith's art possessed by Charlemagne followed him to the tomb. It is said that his body was embalmed, and enclosed in a sepulchral chamber under the dome of the church of Aix-la-Chapelle. He was seated upon a throne of gold, and clothed in his imperial robes; at his side was a sword, of which the pommel as well as the decorations of the scabbard were of gold; his head was ornamented with a chain of gold, in which was enshrined a piece of the true Cross. Before him were suspended his sceptre and his buckler, both also of gold.

These riches attracted the cupidity of the succeeding Emperors of Germany, who took possession of them. Probably the spoilation occurred when, in 1166, Frederic Barbarossa, who had obtained from the anti-pope, Pascal, the canonisation of Charlemagne, took his body from the tomb and distributed his bones, to be enclosed in shrines and reliquaries, as those of the saints. The only specimen of goldsmith's work remaining to us belonging to that great man are his crown and sword.

The calamities that befel Italy, during the 7th and 8th centuries, no doubt prevented the popes from following the example of Symmachus and his predecessors, who had endowed the churches of Rome with valuable gifts of metal-work, and the last act of liberality recorded by Anastasius was on the part of Honorius; but as soon as Charlemagne had, by conquering Desiderius, destroyed the empire of the Lombards, and consolidated the temporal power of the Roman pontiffs, we find Adrian I. giving noble encouragement to the arts, and causing to be executed, for different churches of Rome, a large number of tabernacles, candelabra, lamps, utensils of every kind, and statuettes in gold and silver. His successor, Leo III., far surpassed him in munificence, and the extract made from the book of Anastasius, of the value in weight of the gifts made by him to the churches of works in precious metals, does not amount to less than 1,075 lbs. weight of gold and 24,744 lbs. of silver.

In Italy, the great dignitaries of the Church followed the examples set them by the Popes, and the magnificent altar of gold of the Church of St. Ambrose, at Milan, which has passed uninjured through ten centuries, notwithstanding its immense value, gives a high idea of the importance of the goldsmith's art.

It was not Italy alone that distinguished herself in the 9th century by the magnificent productions of her goldsmiths. France had

preserved the artistic processes transmitted to her by St. Eloy.

Pieces of metal work of the 9th century are extremely rare. Besides the golden altar of St. Ambrose and the crown of Charlemagne, we have only to instance the cover of the "Hours," written for Charles the Bald, between 842 and 869, preserved in the Imperial Library; this cover, which appears to have been contemporary with the execution of the manuscript, is adorned with two beautiful tablets of ivory, finely sculptured in high relief. The one is surrounded by a large border of carbuncled precious stones, set in little plates of silver of an oval form; the other with a tracery of filagree, skilfully arranged, forming a kind of whorled work enriched with precious stones. To judge from the crown of Charlemagne and this book cover, we should be disposed to assert that the accumulation of precious stones was the chief characteristic of the ancient jewellery. In the 12th century, Suger already expressed this opinion.

But the works of the western goldsmiths could bear no comparison with those of the Eastern Empire. Basil, the Macedonian, did not rest satisfied with restoring the worship of images, but decorated the churches with incredible luxury; gold, silver, precious stones, and pearls, were scattered about, if we may credit the narrative of Emperor Constantine Porphyrogenitus, with a profusion which surpasses imagination. Leo the Philosopher, and his son Constantine, whom we have just named, continued to give noble encouragement to the arts, and it cannot be doubted that the goldsmith's art, which had shed much lustre upon the reign of Basil, was maintained at Constantinople in a very flourishing state throughout the 10th century. In support of this opinion, I draw attention to the fact, that it was from artists of this city the Doge Orfeolo ordered, in 976, the celebrated Pala d'Oro of St. Mark of Venice, the finest specimen of enamelled gold work that has been handed down to posterity. The museum of the Louvre possesses an excellent specimen of Byzantine metal work; it is either the top of a box which has served to contain a sacred book, or perhaps the side of a book cover. It consists of a bas-relief, executed in *repoussé* work upon a plate of gold, representing the two Maries visiting the tomb of Christ, where an angel is seated who proclaims the resurrection. Inscriptions in relief relating to the subject form a border round the picture, and some on the ground are taken from the gospels of St. Mark and St. Matthew. The fine character of the figures, the taste displayed in the arrangement of the draperies, and the finish of the execution, bear a favourable testimony to Byzantine skill, and afford a proof that, in the industrial arts, the Greeks preserved, until the 12th century, their pre-eminence over all other nations of Europe.

The 10th century was for the West an age of iron. Calamities of every kind overwhelmed Italy especially, and it cannot be wondered at that, amidst incessant troubles and devastating wars, Wolvinus, who had rendered the goldsmith's art illustrious at the beginning of the 9th century, should have no successors in the 10th.

Yet, in following the researches of the Abbé Le Bœuf, we find that while all other arts were well nigh abandoned, the French goldsmiths pursued their labours during this disastrous period. The Bishops of Auxerre, Gaudry and Guy, treading in the steps of their predecessors, had enriched their cathedrals with new gifts of metal-work. The Archbishop of Sens, Seguin, had given to his church a superb golden altar, more than nine feet long, enriched with bas-reliefs. This magnificent specimen of the goldsmith's art, the execution of which is attributed to two canons of Sens, Bernelin and Bernuin, skilful goldsmiths, existed till 1760, when it was destroyed by order of Louis XV. in aid of the expenses of the war.

The 11th century was a period of renovation; the principles of ancient art had fallen completely into oblivion, and the goldsmith's, which had already departed from them in some of its productions, followed the steps of the other arts. It was necessary for the service of the temples, which arose on every side in a new style, that there should be provided appropriate plate, and the goldsmiths found it necessary to invent other forms for ecclesiastical vessels, and for shrines to contain relics of the saints; the same enthusiasm which led princes, communities, and people to demolish the old churches for the sake of building new ones leading them also to refashion the utensils, and consequently to melt down all the pieces of goldsmith's work. Of this, the great scarcity of ecclesiastical works in metal before the 11th century affords a convincing proof.

The forms then adopted for the different church utensils received the stamp of a severe style, pre-eminently ecclesiastical. Throughout the Middle Ages they preserved this character, which was again altered by the reintroduction of Græco-Roman forms.

In the works of the goldsmiths of the 11th century, as in those of the other arts, we find a certain Byzantine influence which is no matter of surprise. Constantinople was the city, above all others, for the cultivation of the arts connected with luxury, and we have already remarked that it was from Constantinople that Italy sent for the goldsmiths, founders, and chasers whenever, at the end of the 10th century and at the beginning of the 11th century, any large piece of metal-work was to be executed.

Besides, the Eastern Empire and Italy were lhen in close political and commercial relation. Cicognara remarks that the presents made by the emperors and Greek patriarchs in Italy of pieces of goldsmith's work, for ecclesiastical use, revived in that country a taste for ornaments executed in materials of gold and silver.

In Germany a different cause produced the same result. The marriage of Otho III., with the Greek princess Theophania, naturally attracted Byzantine artists to the court of that emperor. These introduced into Germany the style of their school, which was quickly adopted by the various arts, at that time endeavouring to strike out into new paths.

Of this we find a proof in several monuments of this period still existing in Germany. Thus, the Royal Library at Munich contains an Evangeliarium brought from the abbey of St. Emeran at Ratisbon. It was written in 870 by the brothers Berengarius, and Luithardus, by order of Charles the Bald, whose portrait is given in one of the miniatures that ornament the book. This precious volume has been overlaid, in the reign of Otho II., with a rich cover of gold ornamented with *repoussé* figures; in the centre, in an oblong frame, enriched with carbuncled gems and fine pearls. Christ is represented in an aureola, the rest of the field is covered with well-drawn bas-reliefs, remarkable for the fineness of the execution. Notwithstanding the inscriptions on this specimen being written in Roman capitals, one cannot fail to recognise the hand of a Byzantine, such correctness of proportion and symmetry of the figures being confined at that period to the best artists of the Greek school.

When, therefore, Henry II. was elevated to the imperial dignity, he found several Greek artists established at the German Court. We know that the great piety of this prince induced him to present the church with pieces of gold-work of the highest importance, some of which are still extant. The finest of these is the golden tabula, or decorated altar-front, given by him to the Cathedral of Bâle, and which was sold by auction some years since, at the time of the separation into two cantons of the town and territory of Bâle. This altar front, nearly 6 feet wide, forms a Romanesque arcade, where each of the five arches, supported by light clustered columns with scaphoid or cushion-shaped capitals, forms a niche containing a figure of Christ in that of the centre, the archangels Michael, Gabriel, and Raphael, and St. Benedict in the others; Christ gives the benediction with the right hand, and in the left he holds a globe, upon which is engraved his Greek monogram between alpha and omega. The Emperor Henry and his wife Cunegunda are kneeling at the feet of the Saviour. The whole is executed in hammer or *repoussé* work in high relief. The style of this monument differs essentially from that of the Paliotto of St. Ambrose, at Milan.

Among the other specimens of metal-work which we owe to Henry II., are the beautiful covers of manuscripts in the Royal Library of Munich; also the crown of gold of the sainted emperor, and that of the empress his wife, preserved in the treasury of the King of Bavaria.

Moreover, a taste for objects in metal-work was at that time diffused over all Germany, and a large number of prelates followed the example of the Emperor Henry. Among those who caused magnificent monuments to be executed must be recorded Willigis, Archbishop of Mayence, who presented his church with a crucifix of gold of 600 lbs. weight; the figure of Christ was so admirably fitted together that all the limbs could be made to move at their joints, and the eyes of the figure were formed of precious stones. We must mention also Bernard, Bishop of Hildesheim, himself a proficient in the goldsmith's art, as some pieces attributed to him still exist in the treasury of the Cathedral of Hildesheim, viz., a crucifix in gold enriched with gems and filagrees, and two candelabra. When we see Germany producing such magnificent specimens as these, the eulogiums awarded to that country by Theophilus, for its works of gold and silver, can no longer be a matter of surprise. The goldsmith's art was, about the same time, much patronised by Robert, King of France, who richly endowed a number of churches and monasteries he had founded with the productions o fthat art. The French, less conservative than the Germans, have kept

nothing of their ancient metal work. We are, however, inclined to refer to this epoch the beautiful box of the Museum of the Louvre. The golden bas-relief and the general character of the box appear to be of French origin, but the enamels added to its decoration, and set in the same manner as the cabochons that accompany them, are evidence of Greek workmanship.

Theophilus, alluded to above, deserves more particular mention. This writer, a simple monk—"humilis presbyter, indignus nomine et professione monachi," as he styles himself—but an eminent artist, has left us, in his "Diversarum Artium Schedula," a treatise containing the technical processes of almost all the industrial arts of his time. Seventy-nine chapters of the third book are devoted to the goldsmith's art. A perusal of this treatise will enable us to estimate the variety of information required by a goldsmith in the 12th century.

In consulting only the list of tools with which Theophilus enjoins the goldsmith to furnish his workshop, we see that he was expected to know how to grave his metals with burins and scalpers, to execute bas-reliefs and figures in *repoussé* work, and afterwards to chase them; he must himself be able to compose the "nigellum" for filling the incisures of his fine engraving, and to make the *cloisonné* enamels, with designs in gold, mixed alternately with gems and pearls in the ornamentation of sacred vessels; nay, further, it was necessary that he should be a skilful modeller in wax, and know how to cast figures in full relief intended for the decoration of his pieces, and the handles in the form of dragons, birds, or foliage, which he would adapt to his vases. After having described the utensils necessary to the goldsmith, Theophilus enters on the technical part of the art, and selecting as examples the most important pieces of church plate, gives instructions for making a chalice, a cruet, and a censer. This engraving, chasing, and sculpture, these nielli and enamels of which Theophilus explains the processes, were only adapted for vessels of high price, to which none but the nobles, prelates, and rich communities could aspire; but the master forgets nothing, his treatise is complete. To accommodate persons of moderate fortunes, he teaches the manner of making pierced works, of impressing silver and copper with stamps; nor does he even overlook the poor in treating of the decoration of books.

The goldsmiths we have hitherto named were, with few exceptions, monks, and the pieces of metal-work described have all an ecclesiastical character. At the beginning of the 14th century, art emerged from the cloisters and took a wider range; the goldsmith's art from that period was no longer employed exclusively in the service of the church but in that also of rich and noble individuals. Soon luxury made such progress that restrictive laws appeared necessary. An ordinance of 1356, issued by King John, prohibited goldsmith's "d'ouvrer vaisselle, vaiseaux, ou joyaux de plus d'un marc d'or ni d'argent, si ce n'est pour les eglises." But these ordinances were powerless against princes, whom they on the contrary favoured, by giving to them alone the right of possessing a considerable quantity of plate. It is, however, easy to conjure up visions of all these riches by means of the very detailed and well written inventories of two of the richest princes of that age; Charles V and his brother, the Duke of Anjou, King of Naples and Provence. The inventory of the Duke of Anjou especially, possesses this remarkable peculiarity, that, although very voluminous, it is signed with his hand. The royal editor does not confine himself to a dry enumeration of the objects in his treasury, but considering them as so many specimens of art, he describes them with minuteness and enthusiam of an amateur.

The Duke of Anjou delivered an enormous quantity of gold to his goldsmith for the purpose of making him a "nef," the piece of plate in which the nobility of those days displayed the greatest luxury, The nef was a kind of box in the form of a ship, which was placed upon the table of a sovereign or great person; it had a lock to it, and served to contain the goblet and various other utensils for the owner's private use. All these pieces of goldsmith's work were enriched with subjects executed in fine enamelled chasings.

The names of mediæval artists have in our day become the subject of careful inquiry. We cannot better terminate this part of the subject than by giving the names of the goldsmiths in France in the 14th century, who are mentioned in the inventories of the time as having executed the finest of the pieces therein described. These certainly must have been the first masters of the day. They are:—Jean de Mautreux, goldsmith to King John; Claux de Fribourg, who made a gold statuette of St. John for the Duke of Normandy, and a superb cross for the same prince when he became king; Jean de Piguigny, maker of the Duke

of Normandy's diadem; Robert Retour, goldsmith at the *conciergerie* of St. Paul; Hannequin, employed to make the three new crowns of Charles V.; and Henry, goldsmith to the Duke of Anjou.

Nearly all the churches of Germany were despoiled of their specimens of the goldsmith's art at the period of the wars produced by the Reformation. Yet there still exists in the treasuries of some cathedrals, as well as in the museums, many pieces that show that the Gothic style was invariably adopted by the goldsmiths until the first year of the 16th century.

It was only towards the end of the first quarter of the 16th century that the French and German goldsmiths adopted the Italian style, which will next occupy our attention.

The political division of Italy into a number of petty sovereignties, and the liberty enjoyed by many of the great towns, were eminently favourable to the development of the art of luxury. The princes, the great dignitaries of the church, the rich and noble merchants of Florence, Venice, and Genoa, and other opulent towns, all vied with each other in magnificence. The armour of the captains, the plate of the princes and nobles, the jewels of the ladies, the sacred vessels and the decorations of the altars, all furnished incessant occupation for the goldsmiths; so that, notwithstanding the intestine and foreign wars which almost constantly desolated Italy until towards the middle of the 16th century, the art was held in higher esteem in that country than in any other in Europe.

At the end of the 13th century, when Nicholas, John of Pisa, and Giotto, cast off the Byzantine yoke, and raised the arts from their previous state of langour and lethargy, the goldsmith's art would no longer have been esteemed in Italy had it not kept pace with the progress of sculpture, of which it was the offspring; and accordingly goldsmiths were seen following the lessons of the Pisan artists, and ranking themselves among their pupils. rom this period the goldsmith's art made rapid progress in Italy. The goldsmiths increased in number, and when we know the great Donatello, Filippo Brunelleschi, the bold artist of the cupola of the Cathedral of Florence; Ghiberti, who executed the wonderful gates of the Baptistry of St. John; all had goldsmiths as their first masters, and themselves practised the goldsmith's art, we may form some idea of what artists these Italian goldsmiths were of the 14th, 15th, and 16th centuries, and what admirable works they must have produced. But, alas! these noble works have almost all perished; their artistic worth proved no safeguard against cupidity, or necessity, the fear of pillage, or the love of change. But a very few names even of these skilful artists have descended to us, and in making known those preserved to us in the writings of Vasari, Benvenuto Cellini, and others, we can rarely point out any of their works as being still in existence.

In 1286, John of Pisa had enriched with bas-reliefs of enamelled silver the high altar of the Cathedral of Arezzo, where we see the Virgin, between St. Gregory and St. Donato, sculptured in marble. This great master did not rest satisfied with paying a tribute to the taste of his age by these pieces of the goldsmith's art; he even made a jewel, with which he adorned the breast of the Virgin. This jewel, in which were set precious stones of great value, cost the people of Arezzo, according to Vasari, 80,000 florins of gold. It was stolen by some soldiers, and the bas-reliefs of silver and gold have also disappeared.

The brothers Agostino and Agnolo, and Andrew of Pisa, all belonging to the school of John, reckoned many goldsmiths among their pupils, and Andrew in particular rendered great services to the goldsmith's art by bringing to perfection the technical processes of casting and chasing. Thus the early part of the 14th century was one of those brilliant periods of Italian metal work.

Maestro Cione was also a celebrated goldsmith of the first half of the 14th century. Vasari cites among his finest works, and as being something marvellous, a bas-relief, the subject of which is taken from the life of St. John the Baptist, with which he had ornamented the altar of that saint in the Baptistry of Florence. This altar, of silver, was begun in the 13th century, but was destroyed in 1366, to substitute for it the one that still exists. The beauty of Cione's bas-reliefs saved them from being melted, and procured them a place in the new altar, upon which they may still be seen. His death occurred shortly after, in 1330, and the high repute in which he was held is proved by the number of pupils, all artists of merit, that he left behind him. Among these are Forzore d'Arezzo, whose fine translucent enamels upon relief were remarkable for their beauty; and Leonardo of Florence, son of Giovanni, who showed himself a more skilful draughtsman than his rivals, and became the first goldsmith of that city.

At the time in which Leonardo flourished, were commenced the two most considerable monuments of the goldsmith's art that have been handed down to us; the altar of St. James of Pistoia, and the altar of the Baptistry of St. John, at Florence. For more than a hundred and fifty years the most skilful goldsmiths of Italy were engaged on these two monuments, and Leonardo enriched them both with his workmanship. The altar of Pistoia is composed of an immense number of bas-reliefs, statuettes, and figures in high-relief, disposed on several planes. It would be too long here to give a detailed description of this monument; but in order to give an idea of its importance I will describe its general character, and the most remarkable pieces of metal-work it contains.

On the right side of the altar are nine bas-reliefs, the subjects of which are taken from the life of St. James. A Latin inscription, engraved underneath, states them to have been made by Leonardo, in 1371. The bas-reliefs on the left side, which nearly all represent scenes from the Old Testament, are by the hand of the same artist. The shrine, containing the body of St. Atto, is not one of the least precious ornaments of the altar; among other bas-reliefs on it is to be observed; an Annunciation, placed between little columns; it is an admirable work, and was executed in 1390 by Pietro, son of Arrigo Tedesco, to whom we also are indebted for nine half-length figures in a good style. Upon the same line are two prophets, by Brunelleschi, probably the only specimens in metal-work remaining of this great artist. The statue of St. James in silver gilt, executed by Giglio of Pisa, in 1350, occupies the upper plane; the angels which accompany it and the tabernacle are by Pietro Tedesco, who also executed 24 statuettes distributed upon two planes, on the right and left of the statue of St. James. A great number of statuettes embellished the different parts of this monument. The principal are by Nofri, son of Buto; Atto Braccini, of Pistoia; Niccolo, son of Guglielmo; Leonardo, son of Matteo; Pietro, son of Giovanni, of Pistoia; and Pietro, son of Antonio, of Pisa. Other goldsmiths are named among those who, at different periods, laboured at the work; Lorenzo del Nero, of Florence; Lodovico Buoni, of Faenza; Meo Ricciardi, Cipriano, and Filippo. The weight of the altar is estimated at 447 lbs.

I will close this notice of the altar of Pistoia, by calling attention to the fact that among the artists engaged in its execution was a German, Pietro, son of Arrigo. The Germans had maintained their pre-eminence in the goldsmith's art, for Ghiberti, in his memoirs, makes mention of a celebrated artist of Cologne, who had made various wonderful pieces of metal-work for the Duke of Anjou, brother of St. Louis, to whose service he was attached. This goldsmith artist, whose name is not given by Ghiberti, died in Italy under the pontificate of Martin IV. Cicognara also, though often partial from a spirit of nationality, acknowledges that these German artists, who worked in Italy in the 13th and 14th centuries, did not go there to study their art, but rather to practise it.

At the end of the 14th century, two great artists issued from the workshop of a goldsmith, Filippo Brunelleschi and Luca della Robbia. Brunelleschi, having early shown an aptitude for all works of skill, his father placed him under a goldsmith. The young Filippo soon excelled all his companions in the mounting of precious stones, and acquired great skilfulness in sculptured metal-work; it was at this time that he executed the two prophets in silver that form part of the altar of Pistoia; they are works of great beauty. Brunelleschi, feeling his genius impelled him to higher enterprises, soon gave up the goldsmith's art; he became the rival of Donatello in sculpture, and far surpassed that great artist in architecture. The cupola of Sante Maria del Fiore, his highest title to fame, has caused us to forget his other works, which would, nevertheless, have sufficed to secure him pre-eminence among the first goldsmiths of his age.

Luca della Robbia entered early into the workshop of the goldsmith Leonardo, and learned under the direction of that excellent master to draw and model in wax, but his rising talents soon led him to devote himself solely to sculpture, and nothing is known of his youthful performances in the goldsmith's art.

To complete the history of Italian metal-work of the 14th century, I have yet to mention some celebrated goldsmiths, contemporaries of Brunelleschi and Luca della Robbia; Mazzano, of Piacenza; Nicolo Bonaventura, and his nephew Enrico, and the Florentine Arditti.

Mazzano's character was established by a magnificent crozier of silver gilt, more than four feet high, which existed, until 1798, in the Cathedral of Piacenza. It was enriched with bas-reliefs, statuettes, ornaments, and enamels designed with taste, and finished with exquisite

delicacy. This beautiful work, begun in 1388, was not completed till 1416, after twenty-eight years of labour. A few years ago, some fragments of it were remaining in the collection of M. Boselli, upon a reliquary belonging to the Cathedral of the Forli, which contains the head of St. Sigismund. The fine chasings, the nielli, and the enamels with which this reliquary is enriched, rendered it one of the finest specimens of the goldsmith's art of the 14th century.

Andrea Arditi is celebrated by a bust in silver of nearly natural size, serving as a reliquary to the head of San Zanobi, which is seen through a crystal placed on the top of the head, the metal being cut away for that purpose. This bust is enclosed in a magnificent shrine of bronze, a masterpiece of Ghiberti's preserved in the church of Santa Maria del Fiore, Florence. It is only exhibited once a year, on the 26th of January; but it is not impossible to obtain a sight of the reliquary on other days. The sculpture of Arditti is at once noble and simple; he may, however, be accused of stiffness, a fault often met with in works of that period. The execution is very careful; the bust is enriched by medallions finely engraved, upon which are represented some of the saints. Vasari, who passes a high eulogium upon this piece of sculptured metal work, attributes the making of it to Cione, but the inscription engraved upon the bust in Gothic characters, "Andreas Arditti de Florentia me fecit," is sufficient to decide the question.

The 15th century brings under our notice still more distinguished artists.

Lorenzo Ghiberti, son-in-law to Bartoluccio, received from that skilful artist the first principles of the arts of design. When scarcely twenty years of age, he had just left the workshop of his father-in-law to go to Rimini, when he was re-called to Florence by the latter to offer himself to the guild of merchants in that city as a candidate for the execution of the two doors for the Baptistry of St. John. Ghiberti had to contend with powerful rivals, among whom Brunelleschi, Donatello, and Jacopo della Quercia were the most esteemed. But, directed by Bartoluccio, who even assisted him, according to Vasari, in the execution of his piece for competition, Ghiberti produced so fine a work that Brunelleschi and Donatello acknowledged themselves vanquished. The judges ratified the disinterested decision of those great artists, and Ghiberti was charged with the execution of these gates, by which his name has been immortalised. The bas-relief of Ghiberti, still preserved in the cabinet of bronzes of the Florence Gallery, was admirable in design and composition; yet in these respects that of Brunelleschi, to be seen in the same cabinet, was in no degree inferior. Ghiberti owed his victory to the exquisite and finished execution of his bronze, which had been completed and re-touched with all the care which good goldsmiths then bestowed upon the most delicate specimens of their art; and it may be safely asserted that it was to his talent as a goldsmith that he owed his triumph in this competition with the greatest sculptors of the 15th century.

The brilliant success of Ghiberti obtained for him numerous orders for sculpture, yet he never renounced his original profession, but continued during his whole life to execute works connected with the goldsmith's art. Besides the silver bas-reliefs for the altar of the Baptistry of St. John, which are splendid pieces of sculpture, he even worked at jewellery. Thus, in the year 1428, he mounted as a seal for Giovanni, son of Cosmo de Medici, a cornelian of the size of a walnut, engraved in intaglio, which, it was said, had once belonged to the Emperor Nero. The handle of chased gold was in the form of a winged dragon issuing from a cluster of ivy leaves. Vasari extols the finish and beauty of this work.

In 1439, Pope Eugenius IV. employed Ghiberti to make for him, during his stay at Florence, a mitre of gold, weighing fifteen pounds, adorned with precious stones of great value, the weight of which was five ounces and a-half. Lorenzo set all these jewels in ornaments, enriched with a variety of graceful little figures of children and others in full relief. On the front of the mitre was Christ seated on his throne, and surrounded by a host of little angels; on the back part was the Virgin, on a seat supported by angels, and accompanied by the four Evangelists. From what remains of the works of Ghiberti, we can form an idea of the elegant style and extreme delicacy of these precious jewels; and if he is justly considered as one of the greatest sculptors of modern times, he may also be classed among the first of goldsmiths.

The execution of the doors of the Baptistry of St. John occupied forty years to complete, and during these long labours Ghiberti took, as his assistants, young goldsmiths, who became at a later period skilful masters of the

art; among these Masolino da Panicale, Nicolo Lamberti, Parri Spinelli, Antonio Filarette, Paolo Ucello, and Antonio del Pollaiuolo were the most celebrated.

It was in the workshop of the goldsmith Bartoluccio Ghiberti that Pollaiuolo acquired the rudiments of drawing and of the goldsmith's art. He made such rapid progress that he soon equalled his master, and acquired a reputation for skill which enabled him to work on his own account. He accordingly took leave of Bartoluccio and Lorenzo to open a shop in Florence where, for many years, he followed the profession of goldsmith with great success.

We have seen in the treatise of Theophilus that the art of working in niello, which consists in covering with a kind of black enamel the fine incisures of an engraving executed upon silver, had become, from the 12th century, an accessory to the goldsmith's art; and, accordingly, we must rank amongst the goldsmiths Maso Finiguerra, who, towards the middle of the 15th century, enjoyed at Florence a well-deserved reputation for his nielli upon silver. No one was ever known to engrave so many figures in so small a space, and with such perfect correctness of drawing. Among the nielli of silver preserved in the cabinet of bronzes of the Florentine Gallery, may be seen a pax executed by Finiguerra in 1452, for the Baptistry of St. John; this is further curious as being the plate of the first engraving ever printed, and of which the Imperial Library of Paris possesses the only impression. Thus the fame acquired by Finiguerra as a skilful goldsmith was justly eclipsed by the glory of having been the inventor of the art of taking impressions of an engraving upon metal.

Among the artists of the end of the 15th century who, after having been goldsmiths, became celebrated in painting or in sculpture, must be cited Andrea Verocchio, Domenico Ghirlandajo, and Francesco Francia. Verocchio, who obtained an equal reputation as a sculptor, and whose master-piece, the equestrian statue of Bartolomeo Colleoni, still stands in the Piazza of St. John and St. Paul at Venice, had begun life as a goldsmith at Florence; several cope buttons, a vase covered with animals and foliage, and a fine cup ornamented with a dance of children, had brought him into notice, whereupon the Company of Merchants ordered of him, for the altar of the Baptistry, two bas-reliefs of silver, which increased his reputation. Called to Rome by Sixtus IV, to restore, in the Pontifical Chapel, the silver statuettes of the Apostles, which had been destroyed, he acquitted himself of his task successfully; but his studies of the antique in the capital of the Christian world determined him to devote himself thenceforth exclusively to sculpture and painting. He had the glory of reckoning among his pupils Perugino and Leonardo da Vinci.

Domenico Ghirlandajo was the son of Tommaso, a celebrated goldsmith, who had received the name of Ghirlandajo from an ornament in the form of a garland which had been invented by him, and of which the young Florentine women were passionately fond. It was naturally intended that Domenico should follow the profession of his father. His works, which consist principally of silver lamps of great value, were destroyed, together with the chapel of the Anunziata, at Florence, which they decorated, during the siege of the city in 1529. Domenico Ghirlandajo relinquished the goldsmith's art to devote himself to painting, in which he became illustrious. What earned Francia so high a reputation was his skill in cutting dies for medals, and for the coinage, then considered branches of the goldsmith's art. To these pursuits Francia had expressly devoted himself, and until he had attained to manhood had not even touched a pencil. It was therefore by a sort of miracle, for which there had hitherto been no precedent, that the labours of a few years sufficed to place him among the first masters of his time.

To close the list of the celebrated goldsmiths of the end of the 15th century and of the first year of the 16th, we must name Ambrogio Foppa, of Milan, surnamed Caradosso, and Michelagnolo di Viviano.

Caradosso was a skilful goldsmith in every department of the art. He principally distinguished himself by his enamels upon relief, and by the medals he engraved under the pontificates of Julius II. and Leo X. He also excelled in making little medallions in gold, enriched with figures either in full or in high relief, that were worn in the caps or in the hair. According to Cellini, he was still living under Clement VII.

The taste for jewels enriched with little figures either detached or executed in high relief, and covered with enamels, was prominent in Italy in the 15th century. I may point out among the finest a pax preserved at Arezzo, in the treasury of the Madonna. This pax was given, in 1464, by Pope Pius to the Siennese, his fellow citizens, who afterwards

made a present of it to the people of Arezzo.

Michelagnola was one of the most esteemed goldsmiths of Florence, in the times of Lorenzo and Giuliano de Medici. He was in much repute for the mounting of precious stones, and executed with equal perfection nielli, enamels, and works of chasing. Vasari cites, as works of great beauty, his decoration of the armour worn by Giuliano de Medici in a *carrousel* which took place upon the Piazza Santa Croce. The best proof of the merit of Michelagnolo is the eulogium passed upon him by Benvenuto Cellini, of whom he was the earliest instructor.

Benvenuto Cellini was born in 1500. After spending nearly two years in the workshop of Michelagnolo, to whom he had been apprenticed at the age of thirteen, he was placed under Antonio di Sandro, another Florentine goldsmith and artist of great talent. He subsequently worked under different goldsmiths of Florence, Pisa, Bologna, and Sienna, to which latter place he had been banished in consequence of an affray. All the time he could steal from the goldsmith's work he devoted to drawing and the study of the works of the great masters, particularly those of Michael Angelo, of whom he was a passionate admirer,

At Pisa he often visited the Campo Santo, and zealously copied the antiquities it contains. At the age of nineteen he went to Rome. During the two years he passed there, on this his first visit, he devoted himself almost exclusively to the study of antiquities, which he only relinquished to work at the goldsmith's art when he found himself in want of money. It may easily be imagined that, by following this course, Cellini, who was endowed with great intelligience and a lively imagination, soon became a distinguished artist.

In 1523, a new quarrel with his neighbours having forced him to fly from Florence, he retired to Rome, where he resided until 1537, with the exception of some months passed at different periods in Florence, and the time he employed in visiting Mantua, Naples, Venice, and Ferrara. During these fourteen years he established his fame as a goldsmith, and made his most beautiful jewels, as well as the dies for the money of Rome, and the medals of Clement VII. and Duke Alexander. Cellini first went to France in 1537. He was presented to Francis I., but this Prince having left Paris for Lyons, Cellini decided upon returning to Rome. He was thence summoned back again by Francis I., in 1540. During nearly five years which he spent at Paris he executed for the king a large number of fine works, of which the only one remaining is a golden salt-cellar, preserved in the Cabinet of Antiquities at Vienna. Cellini, on his return to Florence, devoted himself to the higher walks of sculpture. It was at this time he cast his bronze statue of Perseus, and the fine bust of Cosmo I., and he also sculptured in marble a crucifix of natural size, which Vasari considers as the finest thing of its kind ever executed. Yet he did not give up the goldsmith's art, and still made lovely jewels for the Duchess Eleonora. After having spent twenty-five years in the service of the Grand Duke of Tuscany as sculptor, goldsmith, and master of the mint, Cellini died in 1561, inadequately recompensed for his great works, but leaving behind him a high and well-deserved reputation. There can be no doubt that Cellini was one of the most eminent of artists, and that during his long lifetime he made a considerable quantity of pieces of goldsmith's work.

I will now briefly notice some Italian goldsmiths who distinguished themselves in the 16th century. Giovanni da Ferenzuola was skilful in his workmanship of table plate and of goldsmith's work properly, so-called, *cose grosse;* Luca Agnolo, a good draughtsman, the best workman that Cellini knew when he returned to Rome in 1523; Pilote, quoted by Vasari as very skilful; Piero Giovanni and Romalo del Tovaloccio, who were unequalled in the art of mounting precious stones in pendants and rings; Piero di Mino, renowned for his filagree work; Lautizio di Perugia, who excelled in engraving seals; Vicenzio Danti, who had executed in his youth—before he had exclusively devoted himself to sculpture—some exquisite works in gold; nor should we omit Girolamo dal Prato, pupil and son-in-law of Caradosso, who worked at Cremona, and was called the Cellini of Lombardy.

From the end of the 13th century till towards the end of the 14th, the goldsmith's art in Italy followed step by step the progress of sculpture, with which it was, as it were, identified. The forms became pure and correct, the style was improving by the study of ancient examples, while the large pieces of metal work for the decoration of churches still preserved a religious character. The 16th century was marked by a decided taste for classical and mythological subjects, in which the goldsmith's art largely partook. The style formed under this influence was well

adapted to jewels and objects of common use, which assumed at that period the most elegant forms; but it proved detrimental to ecclesiastical metal work, by depriving it of that serious stamp which had distinguished it in the Middle Ages.

We have reason to believe that from the beginning of the 16th century the French goldsmiths had relinquished the Gothic style, and adopted that of the Italian Renaissance, being influenced by the artists whom Louis XII. and Francis I. had attracted to the Court of France. Of this we have proof in Cellini's eulogium on the labours of the Parisian goldsmiths. According to his statement, more works were executed in Paris than elsewhere, in *grosserie*, a term which includes church metal-work, table plate, and figures of silver. The works executed by the hammer had attained there a degree of perfection unequalled by any other country.

Cellini's residence in France, from 1540 to 1545, must have exercised a great influence over the goldsmith's art, more especially upon the jewellery, in the execution of which he was unrivalled. All the French jewels were then executed in the Italian style. Mythological subjects, therefore, became much in fashion, and occupied almost exclusively the imagination of our goldsmith-artists. In the absence of specimens, the proof of this will be found in the pretty engravings designed as goldsmiths' models by Etienne Laulne, who himself followed that profession. The exquisite rings of Woeiriot, a goldsmith of Lorraine, established at Lyons, where he flourished about 1560, partook equally of the Italian taste of that epoch. It is, therefore, difficult now to distinguish the Italian from the French jewels of the second half of the 16th century. Very few names of French goldsmiths belonging to the 16th century have been transmitted to us. Mention is made of Benedict Ramel, who executed a portrait in gold of Francis I.; François Desjardins, goldsmith and lapidary to Charles IX.; Delahaie, who was goldsmith to Henry IV. Nor should we omit François Briot, the most skilful artist of his time, although the only examples known of his works are vessels in pewter. Nuremberg and Augsburg became, in the 16th century, the principal centres of the goldsmith's art in Germany. At a later period, Dresden, Frankfort-on-the-Maine, and Cologne alike produced skilful goldsmiths. The goldsmiths of Nuremberg preserved in their productions, longer than those of Augsburg, a certain feeling of German art; but, in the second half of the 16th century, the productions of the German goldsmiths are so confounded with those of the artists of Italy in everything relating to the execution of figures, bas-reliefs, and ornaments, that it would be very difficult to distinguish the one from the other, were it not for the form of the vases, which always preserve a stamp of originality. Moreover, nothing can be more graceful than the arabesques which enrich the German metal work of that period, nothing more exquisite than the little twisted figures that formed the handles.

The decided taste at the end of the 16th century, and especially at the beginning of the 17th century, for these cabinets, and which were made principally at Augsburg, afforded the goldsmith-artists increased opportunities for exercising their talents in the execution of silver statuettes and bas-reliefs with which the finest of these cabinets are very frequently enriched. The goldsmiths of Nuremberg and Augsburg produced also pieces of sculpture often remarkable for their judicious composition, their purity of drawing and finish of execution.

In Germany, a country which has ever been more careful than France of the reputation of her children, a great number of these works have been preserved. The *chambre du tresor* of the King of Bavaria, and the Imperial Treasury of Vienna, contain many pretty vases of different forms, enriched with fine designs and enamelled figures. Nor are the Green Vaults less rich. Among the most remarkable pieces of which the parentage is known, this museum contains, by Wenzel Jamnitzer of Nuremberg, a casket of silver; by D. Kellerthaler, who flourished at the end of the 16th century, the baptismal basin, with its ewer, of the Electoral family of Saxony, considered the masterpiece of that artist; another basin in hammerwork, representing fabulous subjects, and a number of bas-reliefs. The Chamber of Arts of Berlin contains also several pieces of goldsmith's work, among which should be specified the following examples:—By Jonas Silber, of Nuremberg, a cup bearing the date of 1583, ornamented with most perfect chasings; by Christoph Jamnitzer, of Nuremberg, nephew and pupil of Wenzel Jamnitzer, an epergne *(surtout de table)*, in the form of an elephant led by a Moor, and carrying on its back a castle, containing five warriors; by Hans Peglot, of Nuremberg, a medallion portrait of Albert Durer; by Matthaus Walbaum, who flourished at Augsburg in 1615, the statuettes

of silver which enriched the magnificent cabinet made for the Duke of Pomerania.

There are still existing a number of pieces in gold and silver which enable us to appreciate the merit of the goldsmith-artists of the period of which we are speaking. Besides which, in order to supply the places of the silver originals which have been melted, a collection has been made in the Chamber of Arts of various fine bas-reliefs in lead, and vases of pewter, enriched with arabesques and figures, which are considered as proofs or casts from pieces of metal-work of the 16th and 17th centuries.

Among the artists who have most contributed to the good style of the German goldsmiths' work of the 16th century should be also named Theodor de Bry, who was born at Liege, in 1528, and died at Frankfort-on-the-Maine, in 1598. He engraved a number of pretty designs for the goldsmiths. His handles and sheaths of knives are exquisite both in style and finish. Although Theodor de Bry is more known as an engraver than a goldsmith, there is no doubt that he himself chased, in silver and gold, a few of the pieces for which he furnished designs. The Green Vaults possess a silver table, containing five medallions of gold, surrounded with arabesques and heads of Roman emperors; this, which bears the monogram, "T. B.," is considered as his workmanship. Neither should we forget John Collaert, an engraver of Antwerp, born in 1540, who has left two series of patterns for jewels remarkable for their finished execution.

The taste that prevailed in France at the end of the 18th century diffused itself over all Europe; and even Italy herself, at the opening of the 18th century, had abandoned the exquisite style which had characterised the great goldsmiths of the 15th and 16th centuries.

Germany, which had hitherto copied France and Italy so closely, had now completely set aside the traditions of the 16th century. We see in the museums of Germany a large quantity of vases, the bodies of which are formed of mother-of-pearl, of rhinoceros horn, or of the ostrich egg, with mounting of the most singular description. The work is always very carefully executed, the workman skilful, but purity of style has entirely disappeared. Irregularly-formed pearls are conspicuous in the jewel work of the period.

A few goldsmiths, notwithstanding, had, as late as the first years of the 18th century, preserved some traditions of better times, and produced some excellent works. We may cite especially Raimund Falz' and Johann Andreas Thelot. Raimund Falz' was skilful in chasing, and made a large number of medallions and bas-reliefs, the greater part of which were designed for the Augsburg cabinets.

In the Chamber of Arts at Berlin are collected a number of proofs in lead of the goldsmith's work of this artist. Thelot flourished at Augsburg. He has left chasings of considerable merit, and acquired a high reputation by the richness, the taste, and the pure drawings of his compositions. The Green Vaults of Dresden possess of this artist a bowl of very fine workmanship, representing Venus rising from the sea. I cannot conclude this sketch of the goldsmith's art in Germany in the 18th century without speaking of J. M. Dinglinger, who enjoyed in his time a great reputation. Born at Biberach, near Ulm, he studied the goldsmith's art near Augsburg. In his youth he travelled and spent several years in France. In 1702, he went to settle at Dresden, and from that period worked almost solely for the Elector of Saxony, King of Poland. Dinglinger excelled particularly in chasing small figures, which he coloured in enamel. The Green Vaults of Dresden contain his finest works. The most curious of all is the representation, in little detached figures of about from 2 to 2½ inches high, of the court of Aurengzebe, at Delhi. The Great Mogul is seated upon a magnificent throne, surrounded by his officers of state; princes, his vassals, are kneeling upon the steps of his throne, and presenting him with rich offerings, which the officers are eagerly receiving; in the foreground are courtiers and ambassadors from Asiatic princes, attended by a pompous train to pay their court to the monarch, bringing with them valuable presents, among which may be noticed elephants with trappings prepared for war, horses richly caparisoned, camels, and dogs. All these numerous little figures, chased in gold, and enamelled in colours, have been made separately, and the greater number are removable at pleasure. They are distributed over a plateau of silver, upon which the artist has represented three courts of the palace of Aurengzebe. The court in the background, covered with a carpet of cloth of gold, is surrounded with porticos and small buildings, in the midst of which is the rich tent that covers the throne of Aurengzebe. Dinglinger executed this work from drawings brought from India, and from the narratives of travellers who had visited the

court of that prince; nothing, therefore, can be more correct than the costume. The Asiatic ceremonial etiquette is also strictly attended to. Dinglinger's little figures are chased with extraordinary perfection; they have life, movement, and a highly characteristic expression. He was occupied, it is said, eight years at this work, assisted by his sons and his two brothers, one of whom, George Frederick, was a celebrated painter upon enamel; and he also employed fourteen workmen. The Elector of Saxony paid him 58,484 crowns of Saxony for this piece. Dinglinger was completely enslaved by the vitiated taste of his period, and it is grievous to think that an artist of his merit should not rather have employed time and money in producing something which might at the present day be ranked among works of art.

I might have said something about precious stones in this paper, but I see that on April 8th, 1881, Mr. Church, Professor of Chemistry in the Royal Academy, read a paper before this Society on the discrimination and artistic use of precious stones, which contains an excellent list of their names. Professor Church also, in 1883, wrote a catalogue of the Townshend collection of gems in the South Kensington Museum, a hand-book which, though small in size, contains much important material that every jeweller should know.

Now we come to consider the condition of the goldsmith of the 19th century. The word goldsmith means a man that makes jewellery or deals in it. Shall we call by the same name the man that has been learning and studying for twenty-one years (divided into three sevens) to be a jeweller, and the man that has come from an ordinary commercial school, and goes behind a jeweller's counter, and sells jewellery, or what is called jewellery?

The only education I know of in England that a jeweller-shopkeeper receives is in a pawnbroker's shop for two or three years. Now, this man that has been in the pawnbroker's shop thinks that he has received the full education necessary. In fact, he flatters himself that he is more than qualified as a jeweller.

A pawnbroker calls himself a jeweller; a watchmaker calls himself a jeweller; the co-operative stores call themselves jewellers; the linendrapers and hosiers sell jewellery. In fact, almost everybody sells jewellery, and claims to be a jeweller.

But I understand a jeweller to be a man that has studied under a master, or has been an apprentice for seven years in order to learn the elementary education of a jeweller; that is say, the melting of different metals, and forging, the flatting a piece of gold level by hammering; drawing, pulling, and stretching wire; stamping in different ways, pickling; filing for rounds, squares, ovals, equilateral-triangles, and other forms. These are things which very few jewellers of the present day are able to do. The jeweller should know the several ways of pewter soldering and tin soldering; how to use the blow-pipe for different flames, &c.; the way of tying a piece of work with iron binding-wire. He must also understand turning, sawing, a little engraving, carving, some chasing, embossing, frosting, and friezing; polishing in general, of which there are several modes; spanning and annealing; some plain setting; putting in cement and cementing; colouring several ways, and this involves some knowledge of how to use the scratch brush.

The first seven years of apprenticeship will really pass like seven months. Now we come to the second seven years; then the man will commence to do something, and he will begin to realise what he has been doing during the previous seven years. The difficulties will be found to increase, and the second seven years will disappear like seven weeks.

Now we come to another task, which is to understand the different styles of different nations. I should think that approximately there are fifty different styles of jewellery. I will try to mention some of them. There are the various Eastern styles, Etruscan, Greek, Roman, Byzantine, Italian, and the Celtic, and these are divided into sub-styles.

Of course the young jeweller must have learnt drawing, such as elementary geometry, freehand drawing, and some studies from the nude. He must work intelligently; he must learn to know his business, and he must, when he is asked to do any particular work in jewellery, be able to perform the task satisfactorily.

Unless a man studies all the different styles he will not acquire any refinement in the art of the jeweller, and he will not be able to make any true jewellery.

When a jeweller makes his sketches, he has first to consider the style he intends to adopt, that will give him the limit of the extension of the composition. His object will be to produce the largest amount of beauty in the most limited space possible under the circumstances. A piece of goldsmith's work need not necessarily be expensive; it is the style

the design, the form, that will give that grace and refinement which will give one joy or pleasure to look at. The very word itself is derived from the Italian word *giojello*, meaning joy, pleasure to the eye.

It is one thing to make a design for a piece of jewellery in gold work or enamel and gold, and quite another to make a design for the setting of precious stones. The former is like making a panel for a drawing-room, and the latter is like making a tessellated pavement in mosaic.

Often when anyone goes to a jeweller-shopkeeper or manufacturer, and shows him precious stones, if they are white, they are pronounced to be brilliants or glass; if red, they are rubies or garnets; if green, they are emeralds or glass; and if blue, they are called sapphires or lapis-lazuli; if of any other colour or shade, they are called merely fictitious stones; and if white and shiny, of course they are called pearls, or sometimes Roman pearls.

Such is the knowledge of the shopkeeper of the 19th century, as he is seen in Great Britain, and perhaps abroad as well, and this in spite of all our technical education and the advantages presented by the South Kensington Museum, British Museum, and other great institutions. To remedy this, a young man must go into the workshop, and after the first seven years, if he has been in a proper workshop, he will appreciate the advantages of these great and useful institutions, and have a chance of earning from £1 to £5 or £6 per week.

As I said before, let a young man go into a workshop where he can find a good teacher, who ought to be the master, and who, I consider, ought to teach the apprentice. A workman in the shop will not teach a younger man, because, if he is intelligent, the workman is selfish enough not to do his duty in teaching his fellow; for, being advanced in years, he is afraid of being replaced by the younger man.

But now, what inducement is there for the young man to learn his business? Suppose he has been an apprentice, and is very intelligent; he goes into another manufactory where the master knows little or nothing, and the foreman even less.

If jewellers thoroughly learnt their business, we should not have so much foreign rubbish, some of it called "Rococo," with daubs of Aspinall's enamel on it.

It may be said that it is easy to criticise and destroy, but what is the remedy? The remedy that I would suggest is that Government assistance should be obtained, and that all those people who serve the public as shopkeepers or manfacturers must pass an examination in their business, and obtain a certificate, say of first, second, or third class, which the public could see when they were doing business with them.

If a man calls himself a doctor, it is because he has studied medicine; a lawyer, because he has studied law; so it is with the army and the other professions. In all the professions a man must pass an examination. Why is not that rule extended to the jeweller?

Now the jeweller does not receive the education required for business by which he gets his living. This examination, in which a man should make a sketch, produce a piece of work, and describe the style he adopts, should be conducted by a guild of his own trade, and unless the piece of work produced is of good quality he should not receive any certificate at all. That certificate would replace the silver license, and the jeweller would pay an annual fee, that is, provided he wishes to become a shopkeeper or manufacturer. No man could sell any goods as a manufacturer or shopkeeper unless he had given proof of his ability. As it is, a man who knows his business is often passed over unnoticed, and the man who has not received an education for the business he is carrying on is encouraged, and people say, "poor fellow he is very industrious, give him a turn." Now, why did not this man become an apprentice and learn his business? No one would have been jealous of him then.

The goldsmith's art is not a mere business, as the public suppose it to be—it should be an artistic occupation. I affirm that it is a fine art, and one that embraces the fine arts of architecture, sculpture, painting, and music. Everybody knows that a goldsmith makes caskets, vases, centrepieces for tables, and many other monumental objects, which must have a base to form the work.

Is not this architecture? And if the jeweller has not some knowledge of this fine art, his production will have no sense in it; for he must construct before he decorates? Then there are sure to be some anatomical figures, no matter of what description the design may be—is not that sculpture and modelling? And when there is enamel mingled with it—which may be translucent, *cloissonnè*, or painted—is not that painting a picture. Fourthly, music; do not all these things require harmony? This is the goldsmith's art, and is it not the sister

art of those four fine arts; does not a man require to learn all I have described before he calls himself a goldsmith?

"Art is long and life is short."

DISCUSSION.

Mr. HUNGERFORD POLLEN regretted the absence of Mr. Giuliano. Most of those present would know that he was not only a very skilful and accomplished goldsmith, but that he belonged to a very celebrated school, which had done more to revive the goldsmith's art than any other movement in our time—the school of which the late Signor Castellani was the principal exponent. The great achievement effected was a revival of the processes by which the old Etruscan and Greek artists produced the wonderful works which were to be seen in the British Museum, the Louvre, and in South Kensington Museum, and which had been recovered from Etruscan and other tombs. The secrets of this art had been long lost, but were recovered by the researches of certain Italian artists and learned men, who found amongst the remote villages in the Appenines old traditional workmen who still were conversant with the different methods of soldering and joining gold which were practised by the old goldsmiths, some of which had been reproduced. For instance, there was the operation of covering a small surface no bigger than a coat button with fine grains of gold, each of which was put on and soldered separately. There were other pieces in which the decoration consisted in little threads, that looked like the hairs on the outside of a gooseberry, an extremely beautiful process. There was also a wonderful means of subdividing a space by little *cloisonnés*, one-tenth of an inch high, which enclosed pieces of enamel, or stones, or other coloured material. Sir George Birdwood knew probably better than any one what Indian jewellers could do; they also had the same secrets, and carried them out in the most astonishing manner, with hardly any tools except of the roughest sort. They had the same traditions as the old Etruscans. All these secrets seemed to have vanished from the art of Europe until quite recently, and Signor Giuliano was one of those Italian goldsmiths who had had the glory of resuscitating these old methods. It was astonishing to see the beautiful pieces of work which he had produced, sometimes with precious stones, sometimes with commoner ones, but which in his hands produced more beautiful results than the flashing jewels one saw in the jewellers' shops, in which the whole beauty consisted in nothing but the stones, the work being little more than a setting.

Mr. J. SPARKES feared the English goldsmiths deserved what had been said of them in the paper, but perhaps the miserable condition of affairs was to be accounted for by the lack of taste in the buyers. He did not believe taste was wanting in the English workman, but he got very little encouragement on account of the indifference and ignorance of those who formed the mass of his customers. No one of any taste but must have experienced a feeling of disappointment, on looking at the things shown in a jeweller's shop, at the absolute poverty of invention which they displayed. Many years ago he was pretty well acquainted with the conditions of the Clerkenwell trades, and could call to mind certain families of workmen, each of whom had a peculiarity of their own, so that the trade went to one for a setting for opals, to another for brilliants, and so on, and there was a certain individuality in the work of these men. But he was told that that had wholly disappeared. Years ago he reared designers who found more or less lucrative employment in designing for jewellers at the West-end, but they had come to him almost to a man, and said they had now no occupation, and wanted to go to Australia or America, where the jeweller's art was in a better condition. They, one and all, attributed the decay of their art to two or three reasons. One was the lack of buying power on the part of the large middle class; another was the large concentration of the sale of such things in the hands of the stores, which purchased jewellery crushed out in a die in Birmingham by the ton; everything without individuality, what there was in the original design being mostly lost in preparing the die. The result had been the ruin of these individual workers in Clerkenwell, and of the designers who could put together any combination the jeweller might suggest, which had any significance for his customers. As Mr. Pollen had said, it was surprising to see what exquisite combinations in comparatively inexpensive material could be made by the hands of an artist. Art was essentially affected when the mere brute value of so many rubies or diamonds was considered of the first importance in jewellery. The Norwegian jeweller, somewhat like the Indian, still in his mountain workshop spun his silver threads and soldered them, and arranged them in the most exquisite traditional and even individual way. He took the old silver dollars, which were very pure silver, and from that stock made all the material he used; he hammered out the plate, pierced it, divided it, added to it in filagree, rosettes, pins, points, and all sorts of things.

Mr. B. HANNAH said the firm he represented (Messrs. Howell and James) conceived the idea some years ago that it would be well, if possible, to elevate artistic taste in jewellery matters, and spent considerable sums of money upon it; but the scheme was an absolute failure, although they employed some of the best artists of the time, Sir Digby Wyatt and others. They had no

encouragement to proceed, and had to fall back on the old lines as regulated by the law of supply and demand.

Mr. A. J. L. Abbott (representative of Mr. J. W. Benson), said that some time ago he tried, through his friend, Mr. Chapman, to induce Sir Philip Magnus to form a class wherein the rudiments of their art should be taught, but Sir Philip answered that he thought the only place where a jeweller could learn what was requisite to know was in the workshop. When the future archæologist came to look back upon the present age, what would he think of our jewellery? Was there a man connected with the trade who knew anything at all about the optical properties of gems? There were not six persons in the trade who would know six stones if they were shown them. Some rough stones were offered in the market not long since, supposed to be rubies of the finest colour, uncut, for which £10 to £20 per carat were offered, but the moment he saw them he pronounced them to be glass, and in this he was borne out by Professor Rudler, of the Museum of Practical Geology. Unfortunately, he heard afterwards that they had been sold to a respectable member of the trade as rubies. It might be thought that the error arose because they were uncut, but it was not so. A stone sold at a sale of French jewels was brought here lately, for which £1,800 was asked, and various prices were offered, on the supposition that it was a fine ruby, but in reality it was nothing more than a spinel. If men engaged in the business did not understand the stones themselves, how much more unlikely were they to understand anything of those remarkable qualities which underlie each specific gem, and which Professor Church alone, with the exception of Signor Giuliano, had tried to bring before the public. Now-a-days the designs came from the cheapest shops in the trade, and they were produced by the men who could make the greatest number of patterns out of the smallest number of "galleries." These things were displayed by the cheap advertising houses; the smaller men went round and looked in the shop windows and copied them, and the public bought them because they were cheap. There was no taste at all; there were now no men who could produce good work, and if there were there would be no purchasers. Signor Guiliano was a pioneer in the art, and, as usual, his views were looked upon as heresy, though in the coming generation they would be orthodox. He hoped something would be done by the Technical Institute; many millions a year were employed in their trade. Every year thousands of Americans came over here for the express purpose of buying jewellery; they looked at what there was here, and if they did not see what they liked they went on to Paris, and lately he understood that in consequence of newer designs being found there, a great deal of the business had gone there which might have been secured for London.

Mr. Stannus said he had been somewhat misled by the title of the paper, for he had come hoping to get some technical information as to the working of gold, instead of which there had been some valuable suggestions as to the abolition of British shopkeepers, and the substitution of a race of artists; and much had been said about jewellery, which was a subject quite worthy of treatment by itself. Reference had not been made to the Etruscan working of jewellery, and to that, as the root, all jewellery went back. That beautiful process of dropping little drops of gold on to a gold plate, and soldering them, dated back to the Etruscan ime. When he was at Perugia, he saw some Etruscan work, and found workpeople actually pursuing the same traditions of work which, probably, their forefathers pursued in prehistoric times. Goldsmiths' work depended more than any other on the art of soldering; before that, all that could be done would be rivetting, and to the unknown man who discovered soldering they owed all that had been done in jewellery; just in the same way as Gothic architecture took its use from the unknown man who first invented rib-panelled vaulting. With regard to the work itself, the horrible stamped stuff alluded to by Mr. Sparkes, a front and back soldered together, and made to imitate a *lump* of solid gold, was decidedly inartistic. Gold being a precious metal should be dealt with as such, not in lumps, but in extended surfaces, either hammered into plate or drawn into wire. These were two great developments in the art of gold working which ran parallel—wire working, which developed into the Genoese filagree work, and plate working. Two friends of his, finding such a want of clever, scientific workmen, had made goldsmiths' work themselves. Mr. Brett, an Associate of the Royal Academy, was one who made some very interesting work for his wife. Another example was the chain made for the Corporation of Preston by Mr. A. Gilbert, A.R.A., the model of which was exhibited some time ago at the Royal Academy, though this was far inferior to the real thing. That was made entirely following the traditions and capabilities of the material. It was to such men as these they must look to resuscitate the art. Signor Giuliano had referred to this art as including architecture, and there were examples at South Kensington of gold and silver work which imitated architectural forms, temples, little pedestals, and so on; but he considered that the most genuine work was not that which imitated forms in stone or wood, but that which imitated the forms which arose out of twisted plate work, and lopped and twisted wirework. It was impossible to deal with this subject without thinking of the great sacrifices which Signor Castellani had made in its behalf. He would conclude by suggesting that the Company of Goldsmiths might

be asked to take a more active part in the practical development of the art than they had hitherto done. They were a most generous guild, and he believed that if some practical working scheme were put before them, it would meet with their support.

Mr. W. MARTIN WOOD suggested that the Society of Arts itself might institute examinations in the goldsmith's art, calling in experts like Signor Guiliano and the Goldsmiths' Company to assist. The paper had not referred to the question touched upon by several speakers, how to teach good taste to buyers and patrons. This was a vast subject, and almost hopeless; but such papers and discussions as the present were an important means by which those who had any elements of taste in them might be influenced. This paper was singularly comprehensive, and contained a voluminous history of the art. There was only one branch of the subject which he missed, that dealing with cameo engraving, which had lately been revived in England, specimens of which were shown at a recent reception by the Lord Mayor. No one probably was so familiar with Indian art as the Chairman, and he would ask him if he had seen the representation of the Great Mogul's Court, which was referred to in the paper, where the writer spoke of the life-like character of the figures, and all the surroundings of the Court. The nearest similarity to it would seem to be the paintings on ivory and glass at Delhi, which were simply hard, close imitations, and were entirely inartistic.

Sir GEORGE BIRDWOOD, K.C.I.E., C.S.I., said that in the first place he must defend the native painters of India from the attack made on them for their ignorance of perspective. Perspective was not at all essential to the production of artistic effect in painting, and, indeed, scenery and incidents could often be more dramatically portrayed without it. For instance, in English pictures of the Jubilee Procession through the streets of London in 1887, the Queen in her perspective place is often nowhere, whereas in a native Indian drawing the Queen would be represented ten or twenty times the size of every other person around and about her Majesty, and pervade the whole pageant with her presence: which is exactly what her Majesty did in the eyes of all who saw the Jubilee Procession. Perspective is indeed a scientific mode of pictorial representation, in the practice of which the West has attained to great perfection, but it is in no way essential to artistic excellence in painting, as is proved by the high artistic merit of the traditionary painters of the East. It is only absolutely necessary to the illustration of a country in connection with its scientific survey, or for the purposes of an estate agent. In regard to the etymology of the word jewel given by Signor Giuliano, it certainly went back through the Italian *giojello* (a jewel), the diminutive of *gioja* (joy), and the French *joyau* (a thing of joy), to the Latin *gaudium*, although some traced it through the Mediæval *jocale*, to the Latin *jocus*, a toy. Yet he only knew of one place, in any Latin author, in which the word *gaudium* is used in any way in the sense of jewel, namely, in the Preface to Book XX of Pliny's "Natural History," where the words "adamantem opum gaudium" might be translated "the adamas (diamond ?) the jewel (literally 'joy') of opulence." But habitually the Latin for jewel is *gemma*, and for jeweller *gemmarius*; while the Greek for jewel was *lithos*, and *keimelion*, or a thing "laid up in store, *i.e.*, a treasure, and for jewelled, *dialithos*. Evidently the ancient, like the present native Indian jeweller, was, emphatically, a gem setter. All jewellery, as we trace it backward through the Mediæval, the Celtic, Anglo-Saxon, Gothic, Greek, Roman, Etruscan styles, and in Cyprus, and at Hissarlik and Mycenæ, is seen to be derived from the East; and it is deeply interesting to observe how the traditionary forms and methods of Oriental jewellery have been preserved in Europe, even through the so-called "Queen Anne" period in England, and the period of "the Empire" in France, down to the present generation. This is seen by a glance at the collection of the peasant jewellery of Europe made by Castellani, and now exhibited in the South Kensington Museum, and is still more strikingly impressed on one in strolling through the booths at the great fair held in honour of the Blessed Virgin every year at Boulogne-sur-Mer, where the peasant jewellery of every province of France is brought together in the greatest profusion, and its Eastern character is thus forced on the attention of the idlest observer. There could be no deeper degradation than that into which the art of jewellery had in recent years fallen in England. We still had artistic jewellers among us, but they could be counted on the fingers of one hand; and the 2,000 others to be found in the East-end, with the 8,000 who made the name of Birmingham a bye-word all round the world, were no more than ignorant, inconceivably ignorant, and tasteless manufacturers of worthless rubbish of the most affronting vulgarity. The causes of this degradation were many. One was the dis-association in the modern life of Europe of personal ornament from the service of religion. But the chief cause was the competitive spirit of Western civilisation, breathed into it from the first breaking away of the younger Aryas from their ancestral home in Central Asia, and which once and for ever, after the heroic and successful resistance offered by the Greeks to the Persians, differentiated it from the co-operative civilisation of the East. It is hopeless to look to the revival of trades' guilds for a remedy. The guild system is part and parcel of the traditionary co-operative Asiatic economy of life which has gradually been starved out of Europe

under the stress of that individual liberty and right of personal initiative so dear to each one of us, and which has given to us the commercial and political mastery of the world. All that a revival of the guild system can do is to create an *élite* class of art workers in the various decorative branches of national industry. This, however, is a great object, and worth securing; and already, in Germany, a lively interest is being taken in the resuscitation of the mediæval trades' guilds. In this view, it is very fortunate that we possess in the United Kingdom, in most of the old cities and towns, and particularly in London and Edinburgh, a number of richly-endowed guilds that have survived the influences of the modern commercial system; and notwithstanding that until very recently all that they had continued to maintain of their ancient duties was the practice—from which they derive their name—of feasting together, they could readily be inspired with renewed vitality; of which the London livery companies have indeed already shown signs. It is now the turn of Edinburgh to bestir itself, and once again to rally to the cry of "Up with the Blue Blanket," or famous banner of the incorporated craftsmen of the "good town," that for so long has lain ingloriously furled in the Merchant Maidens Hospital. But we must not expect too much from the guilds; for it is quite impossible for them to cope commercially with the mechanical productiveness that has blighted every branch of our artistic industries under the inevitable operation of unrestricted free trade. The long apprenticeship of 21 years prescribed by Signor Giuliano was practically an impossibility. The better plan would be to take a lesson from the Hindoos and perpetuate industries in a family, from father to son, through successive generations. In this way the artisans of India served their apprenticeship, not for twenty-one, but for thousands of years before they were born. They came into the world with their minds bent, and their fingers ready trained to their art, whatever it might be; and we saw the result in the unapproachable perfection of their handiwork. The Chairman then passed a warm eulogium on Signor Giuliano, as a jeweller and goldsmith. Like his master, Castellani, he was learned in every style, and thoroughly scholarly in whatever style he worked. Besides this he had a wonderful power, entirely his own, of giving the highest intellectual and sentimental expression to his jewellry. Quinctilian said that the perfection of art is superior to the costliest material, "Ars summa materiâ optimâ melior." The spirit of this maxim has ever animated Guiliano, who, in his recent paper, has told us that a jeweller's duty is to impress the utmost possible beauty in his materials; and not to endeavour to concentrate as much money value as possible in the narrowest taste, according to the vulgar English canon.

A vote of thanks to Mr. Giuliano was carried unanimously.

FIFTEENTH ORDINARY MEETING.

Wednesday, March 20, 1889; the DUKE of ABERCORN, C.B., Chairman of the Council, in chair.

The following candidates were proposed for election as members of the Society:—

Arnold, Thomas, 19, John-street, Llanelly, South Wales.
Childe, Henry Slade, Wakefield.
Horridge, J. M., care of Messrs. Allen & Co., Caxton-house, Palmerston-square, E.C.
Law, Commander Edward Downes, R.N., 65, George-street, Portman-square, W.
McDougall, James T., Dunolly, Blackheath, S.E.
Rouse, Thomas, 140, Leadenhall-street, E.C.
Syms, William, 58, High-street, Rochester.
Thomas, John James, Ynyshir, Pontypridd.

The following candidates were balloted for and duly elected members of the Society:—

Baillie, Alexander Francis, 13, St. Stephen's-road, Bayswater, W.
Chretien, George Thomas, 4, Russia-court, Milk-street, E.C.
Cox, Ebenezer John, 23, Albany-road, Harborne, Birmingham.
Hoyle, John, Cliff-house, Greenhithe, Kent.
Maryon-Wilson, Sir Spencer M., Bart., Charlton-house, Kent.
Regnart, Horatio Grece, Highgate-lodge, West-hill, Highgate, N.
Thrower, Alfred, 28, Albert-street, Regent's-park, N.W.

The paper read was—

THE OBJECTS AND METHODS OF THE SOCIETY OF ARTS' MOTOR TRIALS.

By PROFESSOR A. B. W. KENNEDY, F.R.S.

If the essence of science may be rightly summed up in the one word "measurement," the work which my colleagues and myself had the pleasure of carrying out for the Society of Arts last September, and which I have now the honour to describe before the members of the Society, may truly be said to be as thoroughly scientific as any work could be; for it really consisted in the making of a detailed series of measurements of quantities of gas, water, coal, heat, work, temperature, pressure, and so forth, extending over many days, and including, I find, over 5,000 observations. The judges have given a kind of concentrated essence of these measurements, and the chief

facts to which they lead, in the report which is already in the hands of members. The Council of the Society have thought, however, that some more detailed statement of the objects as well as of the methods and results of the motor trials, in a form which would be useful and intelligible as well to lay as to professional members, would be desirable. With this view they have done me the honour of asking me to prepare such a statement in the form of a paper. I have had much pleasure in complying with their wish, but may freely confess that the task set me has proved much more difficult than I expected. I am by no means sure how far I have succeeded in steering my way safely between the tempting Scylla of sacrificing everything to making the paper "popular," by taking for granted the complete technical ignorance of my audience, and the still more fascinating Charybdis of making the paper entirely technical, by assuming that all my hearers were trained engineers.

The motors entered for competition were, by the conditions, to be such as were suited for electric lighting. Practically this involved that they should be such as ran normally at a fairly high speed, and possessed also the greatest attainable regularity of running. This regularity formed one of the points which the judges had to examine most carefully. But, of course, the general characteristics of the motors (that is the qualities which they had in common with all other good motors) offered more numerous points for investigation than their special adaptation for driving dynamos. The power they exerted had to be measured, the proportion of this power available for work, as well as the cost in fuel (gas or coal), lubricant and water, of producing the power. All these points could be measured, and were capable of very accurate determination. Some other points which had to be taken into account were not capable of direct measurement, although none the less of very vital importance, *e.g.*, whether the bearing or rubbing surfaces were sufficiently large and sufficiently well made to work well and constantly without overheating; whether the mechanical arrangements, as in the valve gear, &c., were likely to give trouble or not in continuous working; to what extent the gas ignition could be certainly depended on; in fact generally how far the satisfactory working over a few hours or days, if attained, could be taken as a guarantee of satisfactory working under continuous regular duty. It is of course conceivable that an engine might attain a very high economy, and also might work extremely steadily, over a short period, or perhaps during the whole length of a trial, and yet be unsuitable, on mechanical or other grounds, for standing the usage it would receive in continuous practical work, or it might be so constructed that occasional breakdowns might be exceedingly difficult to remedy. If in what follows I do not speak of those points, it is not because I underrate their importance, but because obviously and in the nature of things they do not admit of exact treatment, but must largely remain matter of opinion or argument. Happily, in the cases before us, the judges were able to come unanimously to the conclusion that there was no reason for supposing that the engines which worked so well during trial would not also work well, so far as these points were concerned, under their ordinary conditions.

Now as to the quantities actually measured, and the leading ideas which governed the choice and nature of the measurements made. Those of you who are familiar with the results of chemical analysis know that an analysis is rarely carried out quantitatively to the bitter end. One-tenth, or nine-tenths, or ninety-nine hundredths of the material is actually analysed and its constituents directly determined. The remainder — *i.e.*, the balance between the known and the unknown—is then put down simply "by difference;" nitrogen 80 per cent., or ash 3 per cent., or whatever it may be. In plain English, this means that the nature of the quantity in question has not been investigated directly, but is a matter more or less certainly inferred from measurements of other things. Now, if I had to describe the end and aim of our system of measurement in one word, I think I could not put it better than by saying that it was to measure this difference, or at any rate to reduce it to the "next to nothing," and even then, as Sir Frederick Bramwell has told us, it is our special duty as engineers to watch it with suspicious eye until it fairly disappears into nothingness.

Perhaps, however, our case is more analogous to that of the accountant than of the chemist. The engineer, in this case, deals with *energy*, truly, and not with *matter*, but he has a certain measurable amount of it to account for, exactly as a chemist has a measurable weight, or an accountant a measurable amount of money. The energy and the matter are equally indestructible; with each, equally, whatever amount is received, precisely the same amount must be spent, lost, stored up, or otherwise got rid

of. The solid may become gaseous, the gold may become paper, the heat energy may become mechanical work, but all these changes are mere transformations, not alterations of the quantitative value of the thing measured. In one word, if the performance of a heat engine of any kind be stated in the form of an account, the two sides of the account *must* balance. I believe that we owe the original enforcement of this idea to the distinguished French engineer and experimentalist, M. Hirn, and I had thought at one time of saying a little here as to the history of its growth, but I have found so much else to say that I am compelled to refrain.

One might make up a heat account for an engine of any kind thus:—

	Th. U.		Th. U
Heat which should have been received, viz., total heat of the combustion of the fuel used	100	Heat turned into work	10
		Heat either not received or rejected, *by difference*	90
Total...	100	Total..	100

The two sides of the account certainly add up to the same total, but the result is about as unsatisfactory as it would be if the numbers represented pounds sterling, and the £90 were a trifling discrepancy in a cash balance. It may be that the waste of the £90 is "unavoidable;" possibly no more than £10 out of the £100 could be utilised. Still one would like to know, first of all, how much of the £100 went in lender's commission, paid in advance, or, analogously, how much of the 100 thermal units was never received, owing, say, to imperfect combustion. And then one would feel entitled to press the matter further, and demand some details of the rest of the £90, in order that even if irrecoverably lost once, the wasteful process might not, if such a catastrophe could in any way be avoided, be repeated. We all know that there are some folk who do not see the "use" of accounts, and to whom a cash account such as I have supposed seems quite a proper, if not indeed a normal, thing. It may hardly be believed, but is nevertheless true, that there are people to whom the idea of accounting for the unused balance of heat in an engine still appears an absurd folly; harmless, perhaps, except as being waste of time, but an entirely uncalled for and useless display of what they are pleased to call "theory," a word which is inscrutably supposed to carry with it some intrinsic opprobium. Had it not been that I have heard remarks of this kind made, I should have thought that the great practical advantages of accounting for lost heat, or lost money, were so obvious as to need no proof. I shall certainly not spend time here arguing the point, contenting myself with remarking that the first step towards recovering a past loss or avoiding a future one is surely and certainly to find out how and when and where the loss occurred. We must know, for instance, whether there had been too great a conductivity in the pocket, or in the cylinder, or whether perhaps what seems to have been waste was really mainly legitimate working expenses, and the ten per cent. utilised as high a profit as one could expect to make. For it is to be pointed out that the whole heat is no more available for turning with work than the whole receipts of a railway are available for dividend, and this in spite of our friends who wish to re-use exhaust steam because it contains latent heat, or to reburn smoke because it contains carbon, or who consider water a valuable fuel because of its hydrogen, or who advocate any other slightly disguised form of perpetual motion, neglectful of the fact that energy in the natural world is always being transformed from a higher to a lower form, and that the direct change back again without further expenditure of energy is an impossible one.

Now, first as to the credit side of the heat accounts, that is to say, as to the determination of the whole heat which ought to have been received by each of the engines. In the case of the gas-engines this was, given the necessary apparatus, comparatively simple. The quantity of gas used was measured through standard wet meters, kindly lent for the occasion by Messrs. Alexander Wright and Son, and on the accuracy of these meters I must say at once the whole accuracy of the balance depends. They were most carefully adjusted before each trial, and there is every reason to believe that their errors (if any) were entirely negligible. The gas consumed in the smallest full power trial amounted to over 1,200 cubic feet, and the meter used for measuring it could be accurately read to less than $\frac{1}{10}$th of a cubic foot, so that it may be taken that the quantity of gas used was very accurately known. Next the calorific value of this gas had to be determined, that is to say, the amount of heat which it was capable of giving out if completely burnt. This was determined by chemical analysis, that is to say, the several samples of the gas which were collected through the meter during each trial were afterwards mixed, and analyses made of the mixture. The very

simple form of gas analysis apparatus used was that devised by Mr. C. J. Wilson, and is now placed on the table. I hope that Mr. Wilson may be able, in the course of the evening, to explain and illustrate its working. Its most novel feature is, I believe, the use of only one "laboratory vessel," or vessel into which the various re-agents are introduced, and in which the various chemical processes go on. By very simple means the gas can be transferred direct from this vessel to the eudiometer for measurement, and the laboratory vessel emptied of reagent, and cleaned by water as often as may be required, without disconnecting any of the parts even temporarily. The heating power of the gas was determined by calculation from the results of the analyses. From the very exact correspondence between the calculated heating power of coal and its calorific heating value determined experimentally, there need, I think, be no hesitation in accepting the calculated heating power of the gas as being a true measure of its value. It is very notable, however, that the gas used on different days varied quite measurably in value. On the 19th September, for instance, the value of 1 cubic foot, under standard pressure and temperature, was 626 thermal units; on the 21st September it was 633; while on the 27th it was 624 thermal units. Per pound, however, these quantities varied much more, being respectively 19,830, 19,200, and 19,700. Being given these data, along with the atmospheric pressure, meter pressure and temperature of the day, and the number of explosions made by the engine during the trial, it is merely a matter of arithmetic to find the heat which the engine ought to have received for each explosion, and this figure constitutes the credit side of the account, as given in our report. It may be remarked in passing that the number of explosions in a gas-engine is not so readily found as the corresponding quantity, the number of revolutions, in a steam-engine, on account of the inevitable governor misses. We found it necessary to have the misses actually counted during the whole of each trial, an operation which may be mildly described as tedious to those immediately concerned!

On the debtor side of the account we have first of all a certain amount of heat turned into work; secondly, a larger amount spent in heating the water which passes through the jacket round the cylinder; thirdly, another large amount rejected with the discharged gases up the waste pipe; and, lastly, some very small amount lost by radiation to the atmosphere. The determination of the work done was carried out in the usual manner, namely, by the taking of indicator diagrams at frequent intervals (every quarter of an hour). The number of explosions for each quarter of an hour being known, the total work done by the engine during that time could be calculated, and therefore the rate at which that work was done, or the horse-power. It must be noted, however, that something is still wanted here before the measurement of power can be considered entirely satisfactory. Each indicator diagram is assumed to represent the average working of the fifteen minutes interval within which it was taken. No doubt the average of the 24 diagrams taken during each of the 6-hour trials does very fairly represent the average working of the engine for that time, but within what degree of accuracy it does so we can hardly know until we have some satisfactory instrument for measuring indicated work continuously. None of the instruments which have as yet been devised for this purpose have had a sufficiently extended trial to enable an opinion to be formed as to the extent to which their indications can be entirely trusted. The proportion of the whole heat turned into work varies from 19 to nearly 23 per cent. of the whole heat of combustion of the gas.

The next item upon the debtor side of the account is the heat carried away by the jacket water, that is to say, the water which continually circulates round the cylinder and carries away the heat which would otherwise in a few minutes raise it to a perfectly unmanageable temperature. The determination of this quantity was very simple. The water was run to waste on leaving the jacket instead of being allowed to circulate continuously through tanks, and its inlet and outlet temperatures were measured by frequent thermometric readings. The quantity of the water was determined by a tested water meter. In this way it was found that the heat carried off by the jacket water was considerably greater than that turned into work, lying between 27 and 43 per cent. of the whole heat of combustion at full power. It was somewhat unexpected by me to find that there was no distinct economic difference between the use of a largish amount of circulating water with about 46° or 47° of rise of temperature, and the use of a smaller amount with more than double that rise.

There remains from 35 to 50 per cent. of the

whole heat unaccounted for, of which nearly all is what has been called "exhaust waste," *i.e.*, heat carried off by the gases discharged by the engine; and in the judges' report an attempt has been made to determine this quantity by direct calculation from the indicator diagrams, instead of merely putting it down as a "difference." The data at our disposal make it unavoidable that this calculation should be only an approximate one, but it may be made with sufficient exactness to give most important practical information. If, for instance, the calculated exhaust waste be greatly below the actual exhaust waste by difference, it can only be because the whole heat of combustion has never been received. A "commission" has been deducted, either by leakage or some less obvious cause, from the left-hand side of the account, and it is this which prevents the account balancing. Within my own experience I have been able in this way to predict a possible saving of 20 per cent., and this saving was actually exceeded in practice, while without the calculation referred to the very existence of the loss would not have been known. It would not be suitable that I should here go into details of the methods of calculation, but I may mention a few of the essential points in passing. Any difficulties that exist in the calculations arise from the fact that we have no method of determining by direct measurement the temperatures existing in the gas-engine before and after the explosion. We therefore do not know exactly what volume the gas occupies after it has been drawn into the cylinder and heated by its sides, consequently we do not know exactly the amount of air* necessary to fill the remaining space in the cylinder. Somewhat frequent examination of the matter has led me to believe that the temperature of the charge after it has been drawn into the cylinder cannot differ very much from the highest temperature of the water outside the cylinder. It has, therefore, been assumed that the temperature of the charge after it has been drawn into the cylinder is the same as that of the outgoing jacket water. I may say at once, that if this assumption be wrong by even 10° or 20° Fah., the result is only slightly affected. Once the initial condition of temperature of the charge is thus determined, the ratio of air to gas can be calculated, and the calculations of the temperatures at all the other principal points in the cycle are simple. One finds, of course, that at the end of the cycle the charge leaves the cylinder at a much higher temperature than that at which it entered. To find the heat carried away to waste by the charge it is therefore only necessary that the specific heat of the waste gases should be known. This does not differ much in different mixtures, and can be determined without much difficulty; the remaining calculation is therefore quite simple. Unfortunately, the only quantity which can be calculated in this way is the total heat which the charge had to give up at the end of the expansion. Part of this heat, however, is taken up by the jacket water as the heated gases are pushed out of the cylinder, and therefore is already allowed for in the quantity of heat rejected in the jacket water. If, therefore, we add together the heat turned into work, the heat rejected in the jacket water, and the heat rejected in the exhaust gases calculated in this fashion, we ought to obtain an amount somewhat exceeding the whole heat received (because part of the quantity has been measured twice over), supposing always that the quantity of heat lost by radiation from the engine is negligible, and that the gas has really been completely burned. In one of the engines tested (the Crossley engine) this overbalance was actually found. In another (the Atkinson) I found that there was nearly 10 per cent. unaccounted for, that is, that there was a discrepancy of this magnitude between the quantity required to balance the heat account "by difference," and the calculated value of the exhaust waste. As the heat turned into work and the heat rejected in the jacket water were both somewhat exactly known, and as the calculated exhaust waste was much more likely to err by excess than by defect, one is forced to the conclusion that the discrepancy really lies in an overestimation of the left-hand side of the account, *i.e.*, the heat received. Assuming the arithmetical part of the work to be all right, this deficiency in heat received can only have been due to imperfect combustion, and if this has really been the case we have, to a certain extent, the means of tracing it. For the imperfection of the combustion has not been due to want of oxygen (the composition of the charge was practically the same in the Otto and the Atkinson engines), and so must either have been due to absolute leakage of gas

* We were not able to obtain a meter through which the *air*, as well as the gas for such large engines could be measured directly. Indeed, in the case of a three-cycle engine like the Griffin, this measurement would not have been possible even with a meter, as the air of the "scavenger" charges would have been measured unavoidably with that of the working charges.

somewhere, either in the meter, or in the engine, or in the connections, or to too much delayed combustion in the engine itself. In the latter case investigation of the form of the expansion curve should show us that it was such as corresponded to continuous reception of heat by the charge, in the former we should expect to find the fall of temperature accompanied also by loss, not gain, of heat. For the purposes of the report a very careful examination of this matter was made, which I have since carried considerably further, but with the result only of finding the conclusion stated in the report more thoroughly established, viz., that combustion was going on during the whole expansion, and as rapidly at the end of it as at the beginning. There can, therefore, be no doubt that it still remained incomplete when the return stroke commenced, and here we have at once corroboration of our supposed cause of loss. A similar examination of the expansion curve in the Crossley engine shows, on the other hand, that during the last part of the expansion, at least, the charge has been *losing* and not *gaining* heat, so that the combustion has been practically completed early in the stroke, and this exactly agrees with the result of the calculated balance-sheet. With the third engine tested, on the other hand, the Griffin, the case is intermediate in both respects. There is a small discrepancy (about 4 per cent.) in the heat account (which covers a certain unmeasureable quantity of heat carried away by a scavenger charge of air), and there is also evidence that the combustion continued, to a small degree, throughout the expansion process.

All these points are mentioned in the report, but I have thought it worth while to call further attention to them because of their important relation to what I believe to have been the essence of the system of measurement adopted by the judges, and because they seem to me quite sufficient justification, if justification were needed, of that system. I need hardly point out that in my remarks I have dealt only with the particular engines exhibited, and am in no way generalising from them as to other engines by the same makers. I ought, perhaps, to add that in the various calculations of temperature the small contraction of volume due to the various combinations in combustion has been neglected. I worked out its effect, but found it very small, and it did not appear worth while to encumber calculations which were only approximate with this additional refinement. Its general effect would have been slightly to increase the calculated temperatures.

The process of making out the heat balance for a steam-engine and boiler differs only in its details from that just described. Taking the boiler first, we have on the credit side of the account the calorific value of the coal burned, which can be determined in the same way as before, namely, by calculation from a chemical analysis of the coal. It is, however, possible, without difficulty, to determine the heating power of the coal directly in a calorimeter, and in cases where I have had this done I have found the two determinations, calculated and experimental, to agree within about 1 per cent., the calculated figure being, I believe, the more likely to be correct. This calorific value amounted to 14,200 thermal units per lb., or, weight for weight, about 72·5 per cent. of the value of the gas. So far as the boiler is concerned, none of this heat is expended in doing work; the useful portion of it is spent in heating and evaporating water only. Besides this, heat is spent in raising the temperature of the furnace gases, in raising the temperature of surrounding objects by radiation, and in evaporating the moisture, if any, in the coal. Analogous to the non-combustion of some part of the gas in the gas-engine, we have here also a possibility of an imperfect combustion of some of the coal, of the formation, that is to say, of carbonic oxide instead of carbonic acid. The separate determination of these quantities is on the whole simpler than in the gas-engine. By an accurate weighing of the total quantity of water passing into the boiler, and the measurement of its temperature, and of the pressure (and therefore temperature) of the steam formed, we can say with considerable exactness how much heat has been expended upon the one useful operation, namely, the evaporation of water. The method of determining the heat lost in the escaping gases is not quite so simple, because we have no direct method of determining their quantity, although their temperature can be easily found. We can, however, draw off samples of the chimney gases from time to time and submit them to analysis. This was done during the trials (the samples being taken about every hour), and from the analyses we have found the proportion which the weight of carbon in the gases bore to their whole weight. The weight of the carbon in the gases, however, is simply the weight of the carbon in the coal burned, for there was nowhere else for the carbon to come from. We, therefore, know the real weight of a certain known fraction

(about one-twentieth in this case), of the whole gases passing up the chimney, so that to find the total weight of the gases, and its ratio to the weight of the coal, is a mere matter of arithmetic. The specific heat of the gases can also be readily found, and therefore the quantity of heat carried off by them computed. The analysis of the furnace gases gives us also another piece of information, it tells us whether any carbon passes off imperfectly burned, and enables us to allow for it if it does so pass off. The heat expended in evaporating the moisture in the coal is a very small quantity, and can easily be calculated from the known moisture in the coal, determined by weighing it before and after drying. The loss by radiation from a boiler is very much greater than from an engine, for obvious reasons, so that this quantity is no longer negligible, as it may practically be said to have been with the gas-engines. Its determination is not a matter of entire ease. Perhaps the best approximation to its real value can be obtained by measuring the amount of coal which must be burned upon the grate during a certain number of hours to maintain the steam at a given pressure when the engine is not running, that is to say, when no steam is passing away from the boiler. An experiment of this kind has been used as a basis to determine the loss by radiation in the experiments on the Paxman engine. The loss comes out somewhat large—about 9 per cent. of the whole quantity of heat used—and unfortunately, though in a manner measured, the measurement is not one which can be thoroughly trusted. In the Paxman engine from 80 to 82 per cent. of the whole heat of combustion was expended in actually heating the feed water and converting it into steam; of the remainder, from one-third to one-half was expended in raising the temperature of the furnace gases, the excess of air over that chemically necessary being 52 per cent. in the one case (A_1), and 89 per cent. in the other (A_2). With the smaller quantity of air, however, the combustion was not quite perfect, about 2·7 per cent. of the heat being lost through the formation of carbonic oxide.

The one case in which we have been compelled to leave the heat account unbalanced is that of the steam-engine itself apart from its boiler. We know from the measurement of the feed water the total amount of heat received by the steam, as distinct from the total heat of combustion of the fuel, so that one side of the account is complete. But on the other side we have only one item measured, the heat actually turned into work, and this amounts to only 12·3 per cent. of the whole heat received. The remaining 87·7 per cent. is rejected—thrown away—to a small extent by radiation—but almost entirely in the exhaust. I do not think that any means exist by which the heat carried away by the exhaust steam of a non-condensing engine, in which the steam is used to cause a draft in the chimney, can be measured experimentally.

Any disquisition on steam-engine economy generally would of course be out of place here, but it is right that I should call attention to the figures given on pp. 241-2 of the *Journal*, and to the diagrams in Fig. 19, which show that no less than 35 per cent. of the whole feed was present in the high pressure cylinder *as water* some time after cut off, and that this water was being boiled off, or re-evaporated, all through the high pressure stroke, and again to some extent in the low pressure cylinder, but that at release in the latter there was still about 20 per cent. of water in what may be called the mixed charge in the cylinder. On the other hand, by using the exhaust steam to heat the feed, an amount equivalent to over 15 per cent. of the rejected heat, a larger proportion than has actually been turned into work, is utilised. It will be noticed that the steam jackets were *not* used during the trials.

So far as to the "heat accounts" of the experiments; I must now pass on to the other part of the work. Having measured the indicated horse-power, or work done by the gas or steam in the engine, and found the "thermal efficiency" of the engine by comparing this quantity with the total heat received in each case, we have next to consider the "mechanical efficiency," or ratio of useful work done to the total indicated work. Out of the latter has, in every case, to be provided the work necessary for driving the engine itself, and it might quite possibly happen that the engine having the highest thermal efficiency might lose, or rather nullify, its economy by requiring an undue proportion of the available energy for driving itself. The engine occupies, as it were, the position of the much abused (but very necessary) middleman, and will not allow work to pass through it without exacting its own commission, which, unfortunately, is often a large one. The useful work can be measured by some form of dynamometer, and in either of two ways, viz., by a *transmission* or by an *absorption* instrument. In the former case the work done might be the

actual driving of a dynamo or other machine, and this work would be measured by some apparatus placed between the engine and the dynamo, which would transmit the work while it measured it. Any such apparatus must absorb some fraction (be it only its half-crown per cent. commission) of the whole power, but this could no doubt be determined separately. The reason, however, for which the judges decided against the use of any form of transmission dynamometer, was simply that they knew of no such instrument which could be used on important experiments like these, experiments which were sure to be so much canvassed, and in which errors would be so serious, without elaborate previous calibration by some absorption instrument, or dynamometer which absorbs instead of transmitting the work done on it, which it also simultaneously measures. And if this had to be done there seemed really no particular reason why the absorption dynamometer should not be used directly. The most advisable form of instrument was, of course, a matter very carefully considered. It was finally decided not to use any instrument which had to be coupled up to the engine tested, in order to avoid any possible inequalities in connections, and any additional frictions, but simply to use the fly-wheel of each engine as its own dynamometer wheel, placing on it the simple rope brake which has been described in the report, and which now lies on the table. Now that the trials are over I believe I may say, for my colleagues and myself, that we are quite satisfied with the working of the brakes, and still think that nothing more convenient or more trustworthy than this simple affair could have been used. A self-recording apparatus attached to the spring balance would, no doubt, have been an improvement, but with readings taken every five minutes it may be assumed that at least a better average value was got for it than we are forced to be content with for the indicated horse-power.

I now come to the very important point which I mentioned early in this paper—the regularity of working. The resistance of a dynamo to being turned round may be taken as corresponding to a practically uniform and constant resistance to the rotation of the crank shaft of the engine driving it. But the turning force, or "effort," on the crank shaft, which it receives from the steam or gas pressure in the cylinder, although it must have an *average* value equal to that of the resistance, must yet continually differ from that resistance, falling below or rising above it. In accordance with known dynamical laws, when the effort falls below the resistance, the speed of rotation diminishes; when the effort rises above the resistance, the speed of rotation increases; and these alternate changes of speed are absolutely unavoidable in ordinary engines. (I suppose Mr. Parsons' turbo-motor is the only one in which they are non-existent.) All that engine-makers can do is to endeavour to keep them within the smallest possible limits, either by using heavy fly-wheels, or by subdividing, and so equalising, the impulses of the engine, or by both. In the case of the Paxman engine, where there are two double-acting cylinders working cranks at right angles, the effort on the crank shaft is very fairly uniform in itself, even without a fly-wheel, and may be represented roughly by the ordinates of the wavy line, P P, in the diagram. The Atkinson engine has one single acting cylinder only, and has an explosion only once in two strokes in full work, but as by an ingenious toggle-joint arrangement the piston makes two strokes for every revolution of the shaft, the shaft actually receives an impulse once in every revolution, somewhat as is sketched in the line A A. If the engine be working light, the governor "cuts out" explosions, and one or any other whole number of revolutions may occur without any explosion (A_1 A_1). In the Crossley engine, as is well known, there is in full-power working an explosion every two revolutions, as sketched in C C. If the engine is working light, and makes a miss, instead of one revolution without an impulse there may be one plus two, or one plus any multiple of two, blank revolutions, as is sketched in C_1 C_1. To attain, under these circumstances, the extreme steadiness desirable for the driving of electric machinery, the Crossley engine for which a gold medal has this evening been awarded was provided with the high-speed countershaft described in the report, the effect of which was that the dynamo was driven with absolute steadiness, but at the expense, of course, of a not inconsiderable amount of power, absorbed in the driving of the countershaft itself and its belt. The Griffin engine has one cylinder only, like the other gas-engines, but it is double-acting. At each end, however, in full work, an explosion alternates with two blank strokes, the whole cycle consisting of three strokes, the third one a mere drawing in and pushing out of a "scavenger," or blank charge of air.

This is equivalent to two explosions in every three revolutions, as sketched in the line, G G. When running light an explosion may be missed at either end, or two consecutively may be missed, the number of blank revolutions being two, or two plus any multiple of one and a half, as is shown by G_1 G_1. (The curves are not drawn to scale as to their heights, but merely show how effective and blank revolutions alternate in the three types of gas-engine.)

It was the duty of the judges to endeavour to find out to what extent, if any, the inevitable fluctuations of speed of rotation of the crank shaft, caused by such variable cycles of effort driving a uniform resistance, were seriously detrimental in engines intended to drive dynamo machines. The results of our investigations are given at length in the report. I have been specially asked, however, to show to you to-night the apparatus of Mr. Ransom,* by which we endeavoured to obtain a quantitative measurement of the actual fluctuation of speed within each revolution or cycle of revolutions. This apparatus stands before you on the table, with some of the diagrams taken by it. Although unfortunately the diagrams taken on the trials were rendered comparatively useless by causes stated in the report, I yet do not hesitate to call attention to it, for with somewhat modified details, and on engines permanently fixed down, so as to be free from accidental vibrations, I have obtained excellent results from it both before and since the motor trials, and I know of no other apparatus which will do the same thing.

In concluding this paper, I ought just to allude to one or two other matters. Firstly, I have endeavoured, as will have been noticed, to avoid all direct comparison between the different motors in points which could in any degree be matters of argument. By this course I have, no doubt, deprived my paper, and still more the discussion which will follow it, of the piquancy which always accompanies such quasi-personal matters, and possibly have deprived it of some scientific value which otherwise it might have possessed. I have, however, deliberately taken the motor *trials* as my subject, and not the motors themselves, and I hope that the discussion may run upon the same lines as far as possible. Next, I have heard many expressions of regret that the number of motors which finally came up for competition was so small. I think the judges shared that feeling before the trials began, but I feel pretty sure that by the time they were over, and worked out, and the report finished, both my colleagues and myself had altered their minds on that point as a matter of personal feeling, although no doubt it was a pity, in the abstract, that so many of those originally entered found sufficient cause to retire before the time of trial came on. The last matter is a more important one. It is only right that I should take this opportunity of emphasizing a matter which has, perhaps, been hardly sufficiently placed before the members of this Society, viz., that although the actual carrying out of the trials was in the hands of Dr. Hopkinson, Mr. Tower, and myself, yet the original source of our inspiration, so to speak, was the Committee appointed by the Council of the Society to arrange these matters. The "Conditions of Trial" (Appendix II. to Report) were drawn up by this Committee, and all the judges' proposals as to the methods of carrying out the work were not only submitted to them, but fully discussed and not a little improved by them. The final report was also discussed with them minutely, almost paragraph by paragraph. I perhaps should not say more on this point, but I have felt that I could not leave the subject without at least putting on record the fact that the duties of the Motor Committee were by no means merely formal, but that by their action and advice its members had a very great deal to do with the ultimate success of the trials, although they wisely, as I believe, left the judges an entirely free hand in the executive part of the work.

I should like to add, also, that throughout the trials the competitors showed the most entire willingness to do all that was asked of them, and the utmost desire to assist the judges in making their examination as thorough as possible, and that through the whole of the work there was a notable and complete absence of a certain personal elemeut sometimes painfully conspicuous at competitions of this kind.

I trust and believe that it may be found that these motor trials have had sufficient value, both from the technical and the scientific points of view, to repay the Society of Arts for all the expense and trouble which it has had in organising and carrying them out, and if this is found to be the case, I hope the Society may be encouraged to see its way, on some future occasion, to organise some further investigations of a similar nature, if not precisely of the same kind.

* An engraving of this apparatus, with a description of its action, is given in the Report, see *ante*, p. 243.

DISCUSSION.

The CHAIRMAN said he was sure the meeting had been greatly interested in Professor Kennedy's paper. It had been thought best by the Council that the discussion upon the paper should be taken on the following Wednesday, when Sir Frederick Bramwell would occupy the chair. In the meantime he would call upon Sir Frederick Abel to propose a vote of thanks to Professor Kennedy.

Sir FREDERICK ABEL C.B., F.R.S., said he desired, in the first place, to emphasise the importance of the work which the judges had carried out in connection with these motor trials, and the value of Professor Kennedy's communication. If he had come there quite new to the subject he should have gone away well instructed as to the general nature of the trials and the method of working, and he would congratulate the author on the very successful manner in which he had brought the subject clearly before the audience. He might also congratulate the Council on the success which had attended this their first effort to bring about a competition of this important character. They had hesitated for some considerable time before making up their minds to invite constructors of motors, for the special purpose of electric lighting, to come forward and compete in this way, but they felt that the subject was one of growing importance, and that anything the Society could do to encourage the advancement and perfection of motors would be worth doing. They felt the task was a difficult one, first because it might be difficult to get gentlemen who had devoted themselves to the construction of these engines to come forward and expend time, money, and labour in bringing before the Society and the judges the products of their constructive invention; and, secondly, it would be presumptuous to invite gentlemen of scientific and practical eminence to give the large amount of time and labour which would be necessary in carrying out really useful comparative trials with engines of this description. Nevertheless they were encouraged to attempt the work, and they must be congratulated on the result. It was true that the number of competitors was not large, but the fact that they were all deemed worthy of receiving a gold medal, after their machines had been subjected to the most painstaking and thorough trial, was sufficient to prove that if the quantity was not large, the quality was such as might encourage the Society to devote even greater energy to the further advancement of this work. In appointing the judges, the Council felt some embarrassment, not because there were not many who were most able to undertake the work, but because there were few whom they could venture to ask to devote the requisite time, with little remuneration, for carrying on a series of arduous experiments. They succeeded, however, more easily than they expected, in obtaining judges of the highest eminence. Professor Kennedy, Dr. Hopkinson, and Mr. Beauchamp Tower came forward in response to the invitation, and undertook one of the most valuable scientific and practical investigations which had been made in recent times with regard to the application of power to the generation of light. The special value of this competition consisted in the system which had been laid down and worked out for conducting trials of this description. From the short outline which had been given of the report of the judges, all would agree that this trial had been conducted with a completeness, philosophic spirit, perseverance, energy, and desire to do complete justice to every competitor, which it would be very difficult to excel in any other similar trials. He concluded by moving a very cordial vote of thanks to Professor Kennedy for his paper.

Mr. W. ANDERSON said, as one of the committee charged by the Society with the carrying out of these trials, he must add his tribute of praise to the work which had been done. His position as engineer to the Royal Agricultural Society made it necessary for him to carry out similar trials very frequently, and he might therefore, without egotism, profess to be a competent judge of the way in which such trials were carried out. He had frequently had the opportunity of visiting the trial ground while the operations were going on, and watching them day by day, and he could say most emphatically that trials were never before carried out with such scrupulous attention to accuracy as these were. In the first place, they were not pressed for time, which was a matter of great importance. One of the difficulties at the Royal Agricultural Society was that perhaps ten or eleven engines had to be reported on within a week, and therefore, it was impossible to be so accurate and minute as one would like. In this case, besides the three eminent judges who were there—two of them always, and generally three—there was a large staff of very intelligent observers, and the almost military precision with which the observations were taken at exact times, and the attention concentrated on the work in hand, ensured success. As Professor Kennedy had pointed out, a somewhat new feature in these trials was a rigid balance-sheet, established afterwards. You might say that every possible precaution had been taken, and, therefore, the results must be accurate, but a still better proof of accuracy was to be found in the fact that the results balanced. When he met Professor Kennedy after the trials were over, and the judges had had time to reduce some of the results, he inquired how they came out, and when he was informed that they balanced, that was quite enough to show that no serious error could have been committed, and, consequently, the trials were absolutely trustworthy. More than that, so far as gas-engines were concerned, he believed these were the first trials on record by completely independent judges, who had no ulterior object whatever, except to ascertain the truth. The three engines were of totally different types, and that each one

should have been found worthy of a gold medal was eminently satisfactory.

The vote of thanks having been carried unanimously,

The CHAIRMAN said the Society had also to render its best thanks to the other two judges, Dr. Hopkinson and Mr. Beauchamp Tower, for the able manner in which they, with Professor Kennedy, had carried out their investigations. Having read the names of the firms to whom the gold medals had been awarded, he reminded the members of the conditions under which the awards had been made. It was determined at the end of the year 1886 to offer prizes for the best motors for electric lighting purposes, but the number of competitors who then came forward was not so large as was anticipated, and therefore the matter was deferred until the end of 1887, when certain alterations were made in the conditions, and four gold and two silver medals were offered. Notices were sent to the principal makers of engines, but fewer entries than were expected were received, and the competition was actually confined to the four firms whose names he had read. He thought these gentlemen ought to be praised for coming forward in the way they did.

The Chairman then presented the gold medals—

To MESSRS. DAVEY, PAXMAN AND CO., for their Eight horse-power Compound Portable Steam-engine.

To THE BRITISH GAS-ENGINE AND ENGINEERING CO., for Six horse-power nominal *Atkinson's* "Cycle" Gas-engine.

To MESSRS. CROSSLEY BROTHERS, LIMITED, for Nine horse-power nominal "*Otto*" Gas-engine.

To MESSRS. DICK, KERR AND CO., for Eight horse-power "*Griffin*" Gas-engine.

The CHAIRMAN said he had one other duty to perform, viz., to present a silver cup and 100 pounds to Dr. Meymott Tidy, which was a prize founded by the late Dr. Swiney, and given every five years, for the best work on jurisprudence published during that period. On this occasion the prize had been awarded to Dr. Tidy as the author of a work on jurisprudence, entitled "Legal Medicine." The cup had been executed by Messrs. Garrard, from a design made expressly for the Society by the late Daniel Maclise, R.A.

The Swiney Prize having been presented, the meeting adjourned.

Miscellaneous.

PRESENT CONDITION OF SANITARY SCIENCE.

At the sixth annual dinner of the Association of Public Sanitary Inspectors of Great Britain held at the First Avenue Hotel, Holborn, on the 2nd inst. (Dr. B. W. RICHARDSON, F.R.S., in the chair), the following address was presented to Sir Edwin Chadwick, K.C.B. :—

"We, whose names are appended to this simple but earnest Memorial, beg, on behalf of the members of the Association of Public Sanitary Inspectors of Great Britain, over whom you have so generously and ably presided since the foundation of the society in 1883, and of your many friends and fellow-workers in sanitary science at home and abroad, to tender to you our sincerest congratulations upon your entry into the ninetieth year of your life, and the seventieth of your active public career.

"We should consider it an event historical in character for any one of our friends and contemporaries to have distinguished himself during so long a period in the promotion of any work of public utility; but, when we recall the labours which you have performed, and the objects of those labours—namely, the health of this nation and of other nations, and therewith the happiness, prosperity, and advancing civilisation of peoples everywhere, for all future generations—our pleasure is the greater, not only that one so gifted as yourself should have laboured towards the accomplishment of such extensive and lasting goodness, but that we who have witnessed your efforts should have had the opportunity of testifying to the industry, courage, and enthusiasm, continued to the present hour, by which your efforts have been characterised, and which, from opponents as well as from friends and allies, have long commanded the respect and admiration which are ever accorded to those in whom genius for original observation and suggestion is combined with earnestness of purpose and consistency of action.

"We consider that on your early labours in sanitation, especially your report on the sanitary condition of the labouring classes, and your introduction of the half-time system of education, the present advanced state of sanitation largely rests. And in thanking you for all you have done in the past for the health and happiness of mankind, we pray that your own health, hitherto so conspicuous an example of good sanitation, in its fullest strength and activity, may still long be preserved with every happiness that should to the last attend so honourable, honoured, and useful a life."

The address was signed by a large number of noblemen and gentlemen, to the number of ninety or a hundred in all.

Sir EDWIN CHADWICK'S reply was as follows :—I presume that I may accept the great kindness bestowed on me on the present occasion, partly as having regard to the unusually advanced age of the body, and partly as to the extent of the occupation of the mind, for the promotion of our science during that unusually long period. On the bodily account, it is due to those here, who are practically engaged in sanitary work to state that it will be found on examination that the risks of death and wounds, especially in withstanding epidemics, are fully as great as those sustained by officers of the Naval and in the Military service. I have myself participated in those common risks, and although I probably owe

the duration of such working ability as may yet remain to me, to exceptional hereditariness—for my father died at the age of 84, my grandfather at 95, and my two great-great-grandfathers as centenarians—these facts do not interfere with the point I have named, that men who have to fight for sanitation have sometimes to fight for life also.

Turning from this topic, let me now briefly state the chief present conditions to which we have advanced in the practical applications of our science, which are as yet very imperfectly known. I beg to premise that I state nothing upon hypothesis—nothing but well-examined experiences.

It has been objected that if it were possible to amend communities by Utopias, Utopias would long since have been introduced. Our proceedings—assumed to be Utopian—which I have to recite, are not, however, based upon Utopian ideals, but on "experiences" carefully and separately examined—separately examined as to their assumed and strict application to common conditions. It is no Utopia that death-rates in towns under the separate system of drainage have been reduced by one-half through the work of the sanitary engineer alone. It is no Utopia that the death-rate at Rugby, for example, which was one of the towns first treated by our first General Board of Health, was then 24 in a 1,000, and is now only 19. It is no Utopia that at Salisbury the old death-rate, which at the beginning of the century was as high as 40 in a 1,000, is now about 16; or that at Croydon and a number of other places, death-rates of 24 in a 1,000 now average 15. These reductions have been effected by the system of "circulation *versus* stagnation," which is yet to be made generally understood, to be by constant and direct supplies of water, by the removal of the fouled water through self-cleansing house-drains and self-cleansing sewers, and by the removal of the refuse—fresh and undecomposed, and unwasted—on to the land.

On the examination of incipient experiences, and on long and careful examination, the application of this system was proposed for the metropolis, but it was opposed by what is called "Vestralisation," and by strong interests in expensive works, in the House of Commons, by which the Government, at a morning sitting, were put in a minority. An opposite system was adopted, which has since been examined and condemned by Lord Bramwell's Commission as "a disgrace to the metropolis and to civilisation." Our measure was carefully examined by German sanitary engineers, who proposed it for application to Berlin. It has been applied there, though not yet so completely as I consider it might be, and it has recently been re-examined by a deputation from the French Government, and it is now adopted on that examination for the relief of the sanitary condition of Paris. I greatly lament the loss, by death, of M. Durand Claye, the *ingénieur-en-chef* of Paris, a firm sanitary disciple of mine, but I hope that loss may not imperil the economical execution of the work.

Various experiences in this country, by these factors alone, have established with such certainty that a contractor may contract with safety for the attainment of sanitary results, and by them the general death-rate may yet be reduced by 10 in a 1,000. Beyond the reduction of the annual death-rate from the work of the sanitary engineer, nothing is yet commonly expected or sought for. I had, however, early anticipated that the reduction of the annual death-rate would be accompanied by an advance of the life-rate, and I have recently obtained from the Registrar-General examples of what that advance may be.

I find that at Rugby the life-rate has been extended to all living there, of every class, by eight years, or from 33 to 41 years. At Hastings the duration of life has been advanced for males five years and five months, but for females an average of eight years and one month; at Leek it has been extended by ten years; at Croydon and Salisbury, and other places, the extension has been from six to seven years, females, as a rule, obtaining, by our science, the greatest share—that is to say, some eight years more of life-rate, more of painless life, more of health, and strength, and beauty. These extensions of the life-rates, as yet little known and regarded, belong, however, to all classes, both to the well-to-do and to the lowest. Of the wage classes, whose life-rate is largely the lowest, the extension will be found to be the greatest. To them the greatest gain developed is by the house alone, the "model dwelling," the work of the sanitary architect, giving ten years more of life and working ability, a result cheap to pay for by extra rents, and which would be still further improvable by the removal of surrounding deteriorating conditions, especially bad schools and ill-conditioned places of work.

As against extant evils, there is yet to be provided the due exercise of the functions of medical officers of health and the aid of the sanitary inspectors in the inspection of workshops and schools, and chiefly the half-time schools. As Commissioners of inquiry into the labour of young persons in factories in 1833, it was the recommendation of myself and my colleagues that the factory inspector should be essentially a sanitary inspector. Under our first General Board of Health we made an effort to extend these functions in our regulation of the duties of the local officer of health to a weekly inspection conducted at the places of work. On the detection of the premonitory symptoms of disease — chiefly the eruptive diseases — the health officer would, to prevent them spreading, entrust the removal of the patient to the sanitary inspector, who would be ordered to see to the fitness of the habitation for recovery or to provide a proper place. It is a mark of our progress that such official sanitary qualifications as now abound, which qualifications it is economical to pay for, did not then exist, or were to be obtained in a few instances only, such as that of Dr. Neil Arnott, at such salaries as we could induce a Chancellor of the Exchequer to pay for them.

The greatest and the grandest advance in the power of sanitation made in my time is, it appears to me, that for the extinction of the chief children's diseases, measles, scarlatina, typhus, and diphtheria, an advance which has been carefully and efficiently examined in the chief district half-time schools, where the death-rate, amongst the children who come into those institutions with no developed disease upon them, is reduced to less than 3 in 1000, or less than one-third of the death-rate prevalent amongst the general population. Such reduction is coincident with the reduction of the death-rates in the prisons, the former seats of epidemics, where amongst the persons who enter without developed disease upon them, the epidemics are entirely expelled, and the death-rates reduced below 3 in a 1,000, or to less than a third of the death-rates prevalent amongst the unprotected population outside.

Physicians are beginning to declare that a large amount of the crime for which punishment is inflicted is due to insanity, and that insanity is due to low physical condition which sanitation by early physical training would remove. There are experiences to show that this is the fact. Dr. Ashe and others conversant with the lunatic asylum declare that, as a class, lunatics are of low physical condition, and that that low condition is reducible by sanitation and early physical training, that is to say, of the 80,000 lunatics who now burthen the rates. Of 30,000 blind persons, the late Dr. Rolph declared that two-thirds might have been saved by early sanitation. There are experiences, too long to particularise on this occasion, which sustain these several conclusions.

These experiences are also of vital importance in their application to prison life. But there is another part of our national life and strength which yields the same results. I refer to the latest manifestation of the power of our science for the maintenance of the force of our army. At the Congress of Social Science, held at Liverpool in October, 1858, I proposed that the science which had saved the second army of the Crimea should be applied to the protection of our excessively death-rated army in India, and after much persistent labour of representation, a Commission of Army Sanitary Inquiry was appointed at the instance of Lord Stanley, now the Earl of Derby, in May, 1859, and the change which has since taken place is surprising, even to stolid minds. The old death-rate in the Indian army was 67 in a 1,000. In the last decade it has been reduced to 20 in a 1,000. The saving of life in India in that decade was in men 28,130, in sickness 25,000. This was affirmed, on examination, by Sir Louis Mallet, on a claim for due recognitions, when he was secretary to the India Board. The services of the Army Sanitary Commission, which comprised those of Dr. John Sutherland, and of Sir Robert Rawlinson — the remaining officers of the Crimean Sanitary Commission—were extended over the whole army, and the aggregate saving of life, as returned by the late lamented Professor de Chaumont, of the Army Statistical Department of Netley, has been, in men, 4,058 per annum, and for the decade, 40,500 men; or in money, at £100 per man, £40,053; and in sickness, £41,680, an equivalent sum of £100 per man. The saving in life by sanitation is immensely greater than the losses of life by war.

So much for our own country; but a still greater advance in army sanitation has been made in the German army, where the death-rate has been reduced to 6, and even to 5, in 1,000, with an increased value of 30 per cent. for civil work after three years of military service. We have not yet attained to that increased value of labour, although I have been informed of the value of the labour of the volunteers being increased by five shillings a week by the aptitude imparted by the drill. The foremost sanitation of the German army is largely advanced by a factor which is new to us, but which is extensively available for the civil as well as the military population. Mr. David Grove, the eminent sanitary engineer of Berlin, applied a means of washing constantly half a million of soldiers, with tepid water, at the cost of a shilling for every 100 men. But I find that we now improve upon that sanitation, and can effect it better for ninepence per 100 men. Now, also, in our schools and district institutions about ten children can be washed with tepid water for about a penny, soap and towel included, at a rate of time of three minutes per head—much more cheaply and effectually than they can be washed at home. Trained nurses devoted to the care of patients with the most infectious diseases, have long protected themselves by a double washing, head to foot, daily, with tepid water and a change of clothes, and experienced sanitary officers use the same precautions on the occurrence of extraordinary visitations of epidemics. Populations may now be trained to do the same.

I need not insist here upon the importance of fresh air and good ventilation; but perhaps you will pardon an old man for bringing before you his last pet ideal on this subject. I want, before I leave this earth, to see a project of mine realised of bringing into our crowded communities fresh air from above. The thing can easily be done if our great engineers will only turn their thoughts for a time in the right direction, and build us a few towers—not of Babel confusion, nor of Norman solemnity, but of true aerial altitude; towers of beauty, that shall conduct into the cities and towns from which they rise, the air from above cloudland, sweet as the morning, and the dew of health.

Let me do justice to the intellectual by referring to some of the experiences of the working of the half-time school principle. At the half-time District School of Anerley, and of others of them, excluding absolute idiots, full 90 per cent. are got "to the good,"—that is to say, to wages when they leave of 8s., 10s., and 12s. per week, or nearly the former

wages of adults. When I last visited the half-time school of Manchester, at Swinton, the head-mistress there asked what need they had of emigration when they had three applications for every girl as soon as she was fitted for a place. When the Dowager Empress of Germany visited the half-time school of Norwood, the head-mistress declared that she had the greatest difficulty in meeting the pressing applications for girls for good places. And there can be no doubt that many will be carried to them who would be left with the helpless insane. The late distinguished inspector of schools in Ireland, Sir John Lentaigne, declared that the system, if duly applied, would beneficially change the character of a nation. Lord Shaftesbury has put it on record that the mothers of the factory children in Lancashire had declared to him that the half-time system of school and work had made their children as of another race to them. And this, too, is practicable at a reduced charge from often using the same school buildings for double sets the same day to accommodate industry, as they are finding out they may do in the colonies. And this may be done for £1 10s. per head, with a superior physical training, as against £2 5s. per head, the charge of the long time Board schooling. School teachers have declared that if they were left to their own devices as to classification, they would save three years of school life to every child, and that with a superior physical training which can be got at no time afterwards. This will effect the abolition of the "snail's pace," and will make the school the happy assemblage of the millions of children during the first days of their life.

What may be further attained, by a combination of more effective work of the sanitary architect, with better sanitary inspection of schools and places of work, by the local health officer, with the aid of the sanitary inspector, would, it appears to me, be ascertained by what I have called a close clinical examination, carried out by a competent specialist, as was done with great advantage for Brighton.

The selection of emigrants is now a subject of much consideration, but it may be submitted that one great object would be to ascertain the sanitary fitness of the locality to which it is proposed to send the emigrant, as, for example, that it is not one where the chances of death from phthisis are doubled, or one where, of the children born, more than half will be in their graves before their fifth year—common conditions to which emigrants and their families are now sent.

The orphan children in the district half-time schools are, in a large proportion, the children of hereditary vagrants, mendicants, and delinquents. Our experiences now display a considerable reduction from them of juvenile delinquency, and enable us to declare that if the children of these classes were given to us from very infancy they need be vagrants and delinquents no longer, but honest and productive citizens.

To those who are unacquainted with the subject in detail in principle—the popular test of central legislation and of local administration, of either political party, may be deemed extravagant; yet on due examination will it not be found that the wastefulness of ignorance, of bad central legislation, and of bad local administration, effecting sickness and premature mortality, may actually be tested by the nose; by the odours of stagnation and of putrefaction, by the gases of stagnation, by putrefaction in rooms, by defective supplies of water, by stagnant cisternage which absorbs foul gases, by the odours of putrefaction from sewers of deposit, by the odours of putrefaction from ill-formed and ill-cleansed streets, and by the eye indeed, as well as the nose, in unwashed children and unwashed workpeople in the streets.

In a sentence, low sanitary conditions of populations are everywhere the sources of irritations, of despair, of disorder; whilst high sanitary conditions are the sources of satisfaction, political security, prosperity, order, and peace.

Mr. Chairman, my lords, and gentlemen, I thank you most sincerely for the consolation and happy assurance of the great future which your testimonial conveys to me. Looking further back than perhaps anyone here present can look, I do see, I confess, in the progress of the past, an augury for the future which fills me with all the delight that can fill with the brightness of hope a human heart that has beat so long as mine. I see in the happier because healthier children that are being nurtured, what may fitly be called the new birth of health that is in promise for the world. My satisfaction may not be equal to my thankfulness, but it is sufficient in this respect, that it is a richer satisfaction than has fallen to the lot of most men who have devoted all their energies to the work of national reform in matters that lie nearest to the most vital of all that is national, the vitality of the nation and its power for strength and endurance in the career of nations.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday evenings at Eight o'clock:—

March 27.—Discussion on Professor Kennedy's paper—"The Objects and Methods of the Society of Arts' Motor Trials." Sir Frederick Bramwell, Bart., F.R.S., will preside.

April 3.—"Fruit Growing for Profit in the Open-air in England." By W. Paul, F.L.S.

April 10.—"The Sanitary Functions of County Councils." By Sir Douglas Galton, K.C.B.

Applied Art Section.

Tuesday evenings, at Eight o'clock:—

April 9.—"Architecture in Relation to Landscape." By H. H. Statham. E. C. Robins, F.S.A., will preside.

May 14.—"Venetian Glass." By Dr. Salviati.

FOREIGN AND COLONIAL SECTION.

Tuesday evenings, at Eight o'clock :—

MARCH 26.—"Borneo." By ROBERT PRITCHETT. SIR RUTHERFORD ALCOCK, K.C.B., will preside.

APRIL 2.—"The Argentine Republic." By F. K. SMYTHIES.

INDIAN SECTION.

Friday evenings, at Eight o'clock :—

MARCH 29.—"The Progress of the Railways and Trade of India." By SIR JULAND DANVERS, K.C.S.I. SIR GEORGE BRUCE, P.Inst.C.E., will preside.

MAY 3.—"The Karun as a Trade Route." By MAJOR - GENERAL SIR R. MURDOCH SMITH, K.C.M.G. SIR LEPEL GRIFFIN, K.C.S.I., wil preside.

MAY 24. — "Indian Wheats." By JOHN McDOUGALL. J. M. MACLEAN, M.P., will preside.

CANTOR LECTURES.

Courses of Cantor Lectures will be delivered on Monday evenings at Eight o'clock :—

C. V. BOYS, F.R.S., "Instruments for the Measurement of Radiant Heat." Four Lectures.

LECTURE I.—MARCH 25.—Difference between instruments for measuring radiant heat and thermometers—The black bulb thermometer in *vacuo*—Instruments to measure radiant energy depend upon one of three effects of heat, viz. : expansion, thermo-electro-motive force, change of electric conductivity —Instruments which depend on the expansion of a solid : Cardew's voltmeter ; Ayrton and Perry's voltmeter ; the tasimeter—Instruments which depend on the expansion of a liquid : thermometers ; the *pyrheliometer*—Instruments which depend on the expansion of a gas : the air thermometer ; the differential air thermometer ; Weber's micro radiometer—Rev. A. Bennet's experiments—Joule's thermometer—Other disturbances caused by air currents.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, MARCH 25...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. C. V. Boys, "Instruments for the Measurement of Radiant Heat." (Lecture I.)

Farmers' Club, Salisbury-square Hotel, Fleet-street, E.C., 4 p.m. Mr. Cooke, "Agricultural Experiments Practically Considered."

Geographical, University of London, Burlington-gardens, W., 8½ p.m. 1. Mr. A. F. Mummery, "The Ascent of Koshtantau." 2. Mr. H. W. Holder, "The Peaks of the Bezingi Glacier and Ushba." 3. Mr. C. T. Dent, "Notes on Mr. W. F. Donkin's Last Journey and Photographs."

British Architects, 9, Conduit-street, W., 8 p.m.

Actuaries, The Quadrangle, King's College, W.C., 7 p.m.

Medical, 11, Chandos-street, W., 8½ p.m.

London Institution, Finsbury-circus, E.C., 5 p.m. Prof. Ernst Pauer, "The Characters of the Great Composers and the Characteristics of their Works."

TUESDAY, MARCH 26...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Foreign and Colonial Section) Mr. Robert Pritchett, "Borneo."

Camera Club (at the HOUSE of the SOCIETY OF ARTS), 2 p m. Annual Conference and Exhibition of Apparatus. 8 p.m. Lantern Exhibition.

Royal Institution, Albemarle-street, W., 3 p.m. Dr. G. J. Romanes, "Before and After Darwin." II. "Evolution." (Lecture X.)

Central Chamber of Agriculture (at the House of the Statistical Society, Adelphi-terrace, W.C.), 11 a m.

Civil Engineers, 25, Great George-street, S.W., 8 p.m. Mr. C. E. Emery, "The District Distribution of Steam in the United States."

Anthropological, 3, Hanover-square, W., 8½ p.m. 1. Mr. W. Gowland, "Exhibition of Photographs of Megalithic Remains from Japan." 2. Major C. R. Conder, "Exhibition of Photographs of Megalithic Remains from Syria." 3. Mr. A. L. Lewis, "Rude Stone Monuments in the Country of the Carnutes (Department Eure et Loir, France." 4. Messrs. Joseph Jacobs and Isidore Spielman, "The Comparative Anthropometry of English Jews."

Colonial Institute, Whitehall-rooms, Hôtel Métropole, Whitehall-place, S.W., 8 p.m. Mr. William Westgarth, "Australian Public Finance."

WEDNESDAY, MARCH 27...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Adjourned discussion on Professor Kennedy's paper, "The Objects and Methods of the Society of Arts' Motor Trials."

Camera Club (at the HOUSE OF THE SOCIETY OF ARTS), 2 p.m. Annual Conference (continued).

Inventors' Institute, 27, Chancery-lane, W.C., 8 p.m. Dr. T. Glover Lyon, "The Disinfection of Clothing, &c., by Steam and other methods."

THURSDAY, MARCH 28...Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

Chemical, Burlington-house, W., 8 p.m. Anniversary Meeting.

Society for the Encouragement of Fine Arts, 9, Conduit-street, W., 8 p.m. Professor J. F. Hodgetts, "The Arts in the Pre-Christian Times, amongst our forefathers in Scandinavia and in England."

Royal Institution, Albemarle-street, W., 3 p.m. Professor J. H. Middleton, "Houses and their Decoration, from the Classical to the Mediæval Period." Lecture II.

Telegraph Engineers and Electricians, 25, Great George-street, S.W., 8 p.m.

Sanitary Institute, 74A, Margaret-street, W., 5 p.m. Professor W. H. Corfield, "House Sanitation from a Householder's point of view."

FRIDAY, MARCH 29... SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Indian Section.) Sir Juland Danvers, "The Progress of the Railways and Trade of India."

United Service Institute, Whitehall-yard. 3 p.m. Surgeon-Major J. L. Notter, "The Soldier's Food with Reference to the Health and Efficiency of Service."

Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting, 9 p m. Mr. A. G. Salaman, "Yeast."

Browning, University College, W.C., 8 p.m. Mr. Joseph King, jun., "On Hohenstiel-Schwangau."

SATURDAY, MARCH 30...Royal Institution, Albemarle-street, W., 3 p.m. Lord Rayleigh, "Experimental Optics." (Lecture VI.)

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All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CANTOR LECTURES.

Mr. C. V. Boys, F.R.S., delivered the first lecture of his course on "Instruments for the Measurement of Radiant Heat," on Monday evening, March 25th.

The lectures will be printed in the *Journal* during the summer recess.

Proceedings of the Society.

FOREIGN & COLONIAL SECTION.

Tuesday, March 25; Sir Rutherford Alcock, K.C.B, in the chair.

The Chairman, in introducing Mr. Pritchett, said that a few years ago very few people knew anything about Borneo, or, if they did, their information was very scanty. The last ten years, however, had made a vast difference, and a great many people now were deeply interested in this island, and were beginning to inquire into its history, in connection with which there was a good deal of both tragedy and romance. He did not anticipate that Mr. Pritchett would go much into the past, but would rather narrate what he had seen, as a passenger with Lord and Lady Brassey in the *Sunbeam*, on the last voyage which Lady Brassey made. The public were much indebted to her for many pleasant pictures of foreign countries, and few had passed away more deeply regretted. Mr. Pritchett was a guest on board the *Sunbeam*, and, unlike most casual visitors to Borneo, he saw not only the British portion of North Borneo but also Sarawak, and the remnants of the old native State; and being a keen observer and an artist, he would no doubt have many things to communicate which would be extremely interesting.

The paper read was—

BORNEO, AND BRITISH NORTH BORNEO.

By Robert Taylor Pritchett.

Living, as we do, in an age of remarkably successful colonial development, in which England is certainly not the hindermost, it is only natural that much interest should be taken in those young plants which promise to make a mark in the future, and are likely to supply the wants created for a largely increasing population at home and abroad. The paper I am about to read on the present occasion is not the work of a scientist nor of a specialist, and I trust you will not be disappointed when you learn that it contains only recollections of a very agreeable flying visit to the north of Borneo—a land teeming with natural productions, in which the vegetable world is very prominent. One thing I would ask you to remember, which is that the details are reliable.

Borneo in the south is in the hands of the Dutch. When we get up to Lat. 4° N., we arrive at Sarawak — a territory acquired by the energy and ability of one Englishman; a man whose name will be handed down, and respected by those who come after us, as a great pioneer and grand representative of English energy and perseverance. In our school-days Borneo was little known, and I well remember that one morning, when we had to write geographical couplets, Borneo was given out as the subject. That proved a teaser for many of us, but one youngster was quite equal to the occasion, and summed up the whole question in these two lines:—

> "Rajah Brooke the pirates took, in the war of Borneo,
> And Captain Keppel wrote a book, all about that war ye know."

The young poet afterwards took a double-first at Baliol.

Before entering, or rather skirting, the coast of British North Borneo, we must notice its birth and young history. The country is divided into Dent Province, extreme south on the west side; then the west coast; Keppel Province to the north; Alcock Province and the East Coast Residency on the south-east coast itself.* In 1847, Labuan became an

* The East Coast Residency is now divided into several Provinces, bearing the names of directors of the company, such as the Mayne Wyburg Province, &c.

English colony. In 1877, Mr. Alfred Dent became specially interested, and formed a private association, with concessions of the Sultan of Brunie, 1878. The Sultan of Sulu transferred all his rights to the association for a consideration of an annual payment, and the flag of the Alfred Dent Company was soon flying at the stations of Sandakan, Tampassuk, and Papar.

After Mr. Alfred Dent's visit to North Borneo in person, great interest was taken in the acquisition, particularly by Sir Rutherford Alcock, who had so much experience in Japan; by Admiral Sir Henry Keppel, who knew all about the pirates, and had written on Borneo; and by many others of great influence and experience. The Provisional Association was formed November 1st, 1881, under the seal of Her Majesty Queen Victoria, and the British North Borneo Company started with a Royal charter, much against the wish of their neighbours, the Dutch and the Spanish. Distinctive flags were also approved for the company and its governor, and now the territory is under British protection. Long may it flourish and prosper.

We will start from Sarawak, work round the coast, and then, in conclusion, notice what development has taken place latterly, and what are the leading features of this recent acquisition. The climate in the month of April was enjoyable, and judging from those who have had an experience of ten, twelve, and fifteen years, most healthy. It is true they were blessed with good English constitutions to begin with.

The river leading up to the capital, Kuchin, was, some years ago, rather a good place for crocodiles, and you will agree with me, I think, when I tell you that Rajah Brooke decided to give one rupee per foot for every crocodile brought in dead, and Mr. Crocker told me that during the year 1881 he paid 2,000 rupees, which showed 2,000 feet of crocodiles varying from 4 to 18 feet. Now, from the traffic on the river and other causes, they removed their playground elsewhere. One would think that this supply would make it unnecessary to have so much sham crocodile leather about in our shop windows as we now see.

Sarawak.

The approach to the capital of Sarawak is one full of interest in many ways. The very original way in which each bend of the river has its particular pilotage is very striking, for on one board is seen, in good plain English, hanging from an overbranching tree, the words "Rocks, keep mid-river;" another, "Hug this outside, steer across river;" then "Rocks, hug the shore;" and then the final, "To Kuchin." The river is decidedly narrow and difficult for navigation, being bordered by "nipa" fronds all the way up. About three hours took us up to Kuchin, which is, and ever will be, a monument to remind all visitors of the great work of Rajah Brooke, who, single-handed, formed this settlement, and was made Rajah of Sarawak in 1841. In 1843, Captain Keppel came down with a strong hand upon the pirates who infested the coast. The completeness of Sarawak is very striking, and there is a touch of buccanneering about it, for the fort overlooking the very neat and well-whitewashed tower has its batteries to maintain order in case of requirement. The museum and public buildings show admirable discipline throughout, and any Englishman would be proud of the work carried out there by his fellow countrymen, for the coin of his realm carries the portrait of John Brooke, Rajah of Sarawak. He passed away in 1868, and was succeeded by his nephew, the present Sir Charles Johnson Brooke, Rajah of Sarawak, who went forth in 1870 with an army of Malays and Dyaks to punish a marauding and decapitating tribe of Dyaks in the interior. The territory has about 380 miles seaboard; population 240,000; and an area of about 30,000 square miles.

The Art of Fire Production.

It is always a matter of interest in an unknown land to find out how the natives produce fire. The South Sea natives do so by the friction of dry hibiscus wood—a pointed stick rubbed into a slot is their method. The Fuegans strike two pieces of pyrites into scrapings of berberice stems. The Gaucho of the Pampas, with an elastic stick of about eighteen inches, presses one end against his chest and the other end pointed in a piece of dry wood, then turns rapidly the bow, as in days gone by drilling holes was accomplished, but Borneo is more scientific, and carries the palm. Professor Faraday referred in a lecture to the production of fire by compressed air. In Borneo, a wild tribe of curious habits—the Kyans, in Sarawak—have always done so with a kind of popgun, of which I am glad to be able to produce a specimen this evening, kindly lent to me for the occasion by Mr. Quintus Buck, of the Sarawak service, who is

now in England. Lord Elphinstone has a very fine specimen in his collection, and the British Museum possesses two; but from other parts, one from Sumatra, from Fort Vanda, Capelle, a very beautiful specimen with tinder-box on top, and carved in black horn; and another from Burma, in the north part of Irrawaddy river, Kachyen district.

There was one in the British North Borneo collection in the Colonial Exhibition; but when there was such *embarras de richesse*, so many rare things to be seen, so much to learn, it was impossible to see them all; in fact, the Colonial Exhibition was too soon dispersed, and the public thereby lost much.

The Milanos used head-flatteners of board to alter the shape of the head. When very young, the poor little babes are strapped down on a board, and the flattener applied.

The rajahs had collected some very fine specimens of cannon; but when we arrive at Brunie, their original homestead, we shall refer more fully to them.

Leaving Tanping Pulo, at the mouth of the Sarawak river, passing to the northward, several groups of "nepa" palm like little islands were passed, washed out of the rivers Barram and Rajang, and the wind blowing the fronds over, they look very like native craft under sail.

Labuan is an English colony, with capital government organisation and a governor, and a church, and a prison with nobody in it; but not much doing, because there is nothing to do. There had been hopes of coal here, but these hopes were disappointed. The supply of coal from Muara mines in Brunie Bay, however, has turned out so well that, after all, Labuan is at the present time a coaling station, and the steamers call there to draw supplies from the depot instead of having to diverge to Muara itself. Opposite to Labuan is the *habitat* of that most beautiful bird generally known as Bulwer's pheasant, or *Lobiophasis Bulweri*, and is found inland in the mountains of Lawas river. And now south-east to Brunie, up the river.

Brunie is really a most pleasant thing in its way. The Brunie river is beautiful. The approach to the city is full of historical interest, too, as the spot where Captain Keppel built his fort when the Sultan ran a sort of wall across the river to keep him out. It is so truly Malay, and such a centre of old Borneo, that nothing but a long visit could unfold its wonders of bronze cannon, used as money in the case of small cannon of 24 in. to 3 ft.; ironwork; whistling kettles; Perang blades; betel knives; loom-work of gold tissue, most beautiful; gold earrings like champagne corks, jewelled on the top; brasswork; highly ornamented old betel boxes of beautiful ornamentation; and, finally, a water city of gigantic hats some 4 ft. in diameter. The centre of the river is the high street of Brunie, and the markets are held on the water. Such a perspective of moving hats that nothing else can be seen but much can be smelt. The water is decidedly not clear. Here much sago is manipulated, and a large trade done in it. The houses are all built on the lake-dwelling Malay system, all thatched with "attaps" of nipa palm, and they really look most fragile. When the Sultan passes in procession with all the Pangerans, his suite, flags flying, with gorgeous State umbrellas, and flashing weapons, and splashing paddles, it must be a fine Eastern sight of gorgeous ceremony. In Brunie bay are the Muara coal mines, which seem to promise fairly well, well enough, however, for a Russian man-of-war, which happened to be passing down the West Coast just to look and see if the charts of that part of the coast were quite correct. North of Brunie we pass on, and British North Borneo commences on the sea-coast in Brunie Bay, about Lat. 5° N., extending to 7° 30′ N. This part is in the "Dent Province," with Labuan on the West. The area of British North Borneo, with the islands, is about 31,000 square miles, having a coast line of 1,000 miles. To give some comparative data we would mention the area of Ceylon, 24,702 square miles; Johore, 20,000 square miles; Perak, 8,000 square miles (Straits Settlements).

Going north from Labuan, passing Kumanas Bay, Kapar, we run up to the coast of Keppel province, which is very fine. South-east of Gaya is a very fine harbour with fresh water. Dusun, agriculturist. Putatan has three entrances, with a depth of six fathoms, next to the northward. Approaching Amboug is, to the true lover of all that is grand and beautiful in nature, an anxious moment, for this reason, that he is drawing near to the most magnificent mountain of peaceful solemnity and majesty, Kina Balu, or "Chinese Widow," the pride of Borneo, and regarded with religious awe by such of the tribes as have any religious feeling at all. This glorious mountain, rising 13,700 feet from a low undulating country, is about twenty-five miles from the west coast. To be seen to advantage, it should be viewed from the west side at dawn of day, and watched

until wrapped in the vapour drawn up from the lower grounds as the sun gains power. By a most favourable combination of circumstances I saw the dawn break; the light gradually creeping up, the "Chinese Widow" veiled in the most delicate pearly grey, reminding me of an admirable remark Gustave Doré once made to me, "Les tons gris, mon cher, sont la poèsie de la nature;" and then, as the light developed, the vapour began to rise round the lower part of the mountain, and then by the increased warmth was gradually drawn up between the crags of the broken summit. Kina Balu was indeed imposing and impressive; she stands all alone in every sense of the word.* The "Chinese Widow" is almost the mother of pitcher plants and the *Nepenthes* generally, but I believe the *Nepenthes rafflesiana* came from Singapore, at all events, the name suggests it. Messrs. Veitch made great efforts to bring some over here, and one *Nepenthes lowi* was very remarkable in form, more like the chatty of India. Kina Balu has been partially ascended by three travellers, Lobb, Low, and St. John; but I believe the summit was really only reached last year by Mr. Whitehead, who, according to the *Ibis*, an ornithological magazine, has not only achieved that, but brought back many unknown varieties of the feathered tribes of British North Borneo, after several years' hard work exploring. So, in due course, we may hope to know much more about his explorations in that interesting region.

Before leaving the higher regions of Borneo, note should be made that although Borneo is so near those volcanic islands, Java and Sumatra, where there are twenty-one live volcanoes at the present time, yet there is no single volcano, active or extinct, to be traced anywhere, and no earthquake has been felt, although the sound of Krakatoa was heard at Sandakan, a distance of some 700 miles. Above Gaya we pass Ambong Bay—Abai—the early station of Tampassuk River, with Fort Alfred on that river.

Mantanani Islands, on the north-west coast, have edible bird-nest caves, inhabited by nest collectors during their season.

Passing on to the north, we arrive at Sampanmangio Point, extreme north part of British North Borneo; which used to be the great rendezvous of Bajans, sea gipsies, and pirates, and there was some doubt as to whether it would have been better and more complete had we seen a few of them as they used to be in old days. North of this point lies the island of Balambangan, where, during the last century, A.D. 1775, the East India Company's settlement, consisting of about 100 men, were all massacred by Sulu and Illanun pirates. An account of this is given, I believe, in Belcher's "Voyage of the *Samarang*." Banguey, a much larger island, lies to the eastward of it, next Marudu Bay, with an important station of British North Borneo. The resident here is Mr. Llewellyn Davies, and the town, or rather station, is situated on the west side of the bay, in the Alcock territory or province, 73 down south. The resident's house being on a bluff, commands a grand view of Maraou Bay; it is admirably chosen as a site, and the views from its verandah are very beautiful. Kodat is rather a sporting neighbourhood, if one might apply such a term to a place where pirates were but a short time since in full force; and a crocodile quite recently snatched a pony and mangled him to death. This north part of British North Borneo has the wild cattle and Sambur deer somewhat abundantly. Round the northern part of Borneo, passing through Banguey Channel and Mallawailá Channel, full of coral clusters, and most difficult of navigation, and coasting the Alcock Province —so named in honour of Sir Rutherford, our Chairman to-night—we come down to Sandakan, which may be called the capital of British North Borneo. Certainly, Sandakan harbour is a very fine one; good anchorage, plenty of water for large craft, with plenty of rivers running into it; a matter of great importance for water traffic, as the dense juugle has not yet been "roaded up," and the mara tract travelling difficult. Sandakan lies about lat. 5° 50′ N., long. 118″ E., and in many maps is marked as Elopura, but Sandakan is the name known by the natives, so that name we shall retain.

The Government House is an admirable building, and the kindness of Governor Treacher adds much to the pleasant associations of the place, which has a hospital, church, museum, a very experienced doctor, a land commissioner of great exploring powers, and an officer of the port. This will be a great timber centre, and a large business is carried on by the firm of Abrahamson, at Kapuan, a little to the south, and the depth of water in San-

* It may be very unpoetical to say what the "Chinese Widow" is made of, but I understand that the superstructure is syenitic granite, with extremities of hard shale and greenstone.

dakan Harbour is sufficient for the largest timber ships.

Woods.

The principal and most useful wood is "bilian," or iron wood. Its characteristics are these :—hardness, density, and the being ant-proof. Logs run from 2 ft. 3 in., to 2 ft. 6 in. square and, say, 40 feet in length. It is the best shingle wood, and most valuable timber, being large and plentiful. Other sinking woods, such as russock, grealing, and mirabou, the latter a heavy, dark, yellow wood, valuable for furniture, and taking a fine polish. Camphor wood also, and a red wood, sirayah, which gives logs 5 feet in diameter and 40 feet long; in fact, the woods of Borneo are so various that, as yet, they are comparatively little known. Some of them are already in demand for Australia, and so good a customer so near to Borneo will work, we trust, for mutual benefit.

Gutta-percha is the hardened sap or juice of several forest trees; *Dichopsis gutta* is the scientific name of the one yielding the best quality, and the gutta is brought in by the natives, in pieces formed much like timber wedges, for easy porterage.

India-rubber is the sap of a creeper of the genus *Willoughbeia*, a mighty creeper running to 3 or 4 inches in diameter; it seems to be generally spread all over the country, but more is heard of gutta-percha than india-rubber.

Other Palms of Swamp Production.

As the palmetta is the most useful in Ceylon, so the "nipa" is found in Borneo. Above the mangrove, and where the water begins to be brackish, the "nipa" commences, and large swamps of them intervene between the mangroves and the true land. Where the water is more fresh than salt, there they revel, and the leaves grow boldly and imposingly to a height of twenty feet and upwards, in fact, like gigantic ferns. House-thatching in Borneo is principally of these fronds stitched together, and are called "attaps." These roofs seem particularly adapted to the resistance of the heat of the climate, and the winds are never strong enough to disturb them when once fixed. The Kadjan mats, so useful for travelling, are made from these fronds, and they fold up into the smallest possible compass. The divisions in the houses are also made of this material. The young leaves are unfolded and dried, and are used for cigarette covers, and the fruit is eaten by the natives.

We have yet to refer to another palm, the "nebong," a nearly fresh-water growth, rising to nearly forty or fifty feet. Nearly all the lake dwellings, like Malay houses, are built of this wood, which is plentiful. Nearly the whole of Brunie water city, with its population of 20,000, is built with these palms. The head, or cabbage, formed of unexpanded leaves, is considered a delicious vegetable, and fine tankards are made with the joint forming the base.

Rattans.

Our general idea of rattan runs rather to canes and walking-sticks, and we have very limited ideas of innumerable uses of rattan in its native land. The rattan of commerce is the *Rotan saga*, and the principal source of supply is from the Kina Batangan River and Labuk, in the East Coast Residency. The native plaiting of the strips of rattan is very beautiful, and at a first glance may be taken for plaited sinew or leather, as seen in the belts for carrying "parang ilang," and as strong twine, cord, and rope generally. In their canoes the out-riggers are all lashed with this very tough and lasting material; in fact, without this, the natives could not do their nest collecting for want of flexible ladders.

Sago.

The native name of sago palm is "Rumbiah." These palms grow to from 20 to 50 feet, generally along the banks of rivers and in swampy land. There are two kinds, *Metroxylon Lævis* and *Metroxylon Rumphii*, the latter is especially favoured by nature by being naturally protected from its incessant enemy and devourer, the wild pig. It is armed with strong long spikes; and in cultivating sago nothing but strong good fences of Bilian wood will keep out these burglars of the forest, for where they are bent on sago it takes a good deal to stop them and keep them out. Sago is a leading feature in Borneo, and when it is known that seven-eighths of the supply to Europe comes from Borneo, no apology will be required for mentioning a few facts relating to its growth, its manipulation, and its markets.

Three trees supply more nutritive matter than an acre of wheat, and six trees more than an acre of potatoes.

Our sago is a fine white flour obtained from the heart of the palm in the following manner:—Just before the terminal spike of the inflorescence appears, which grows to four or five feet in length, about six or eight years after

planting, the palm is cut down at the root, divided into lengths to suit the manipulator, each length split in two, when the pith is scooped or dug out with bamboo hoes, a thin skin or rind only being left, and that forms generally at Brunie a canoe for the amphibious youngest child, as "papa" is frequently requested to leave the ends standing.

The pith is placed in mats over a trough or canoe by the waterside, and water being constantly poured over it and trodden out by the natives, a rough separation of the starchy matter from the pithy woody matter is arrived at, and the former runs off into troughs below, while the latter remains on the mat for the pigs, &c. The raw sago is sold to our useful friends, the Chinese, who put it through many washings, and send it to Singapore, and it finally reaches our nurseries.

Sago is highly appreciated in its own country, for it is much used in the home circuit, and is really a favourite article of food in Borneo. It grows vigorously, most vigorously in damp localities, but, like everything else, has its fancies. A full-grown tree of six years will produce 200 to 300 lbs., and even more, of pith sago flour, which, boiled into a paste called boya, is eaten in lieu of rice. If the palm is allowed to flower and seed, like the talipot, or great fan palm of Ceylon, the pith is dried up and it dies. The talipot in full flower is simply magnificent in Ceylon. Each sago palm gives out numerous offshoots, which takes the place of the parent tree, so that a sago plantation once started is, to use a modern term, quite automatic after the first start of six or seven years.

The following estimate of cost and production is taken from the report of Mr. W. M. Crocker, who went out as Governor of Sandakan in 1887, after very many years of experience in Sarawak and the Indian Archipelago:—Sago plantation of 500 acres. Estimate for planting and bringing to maturity, say, $18,800, including keeping up, care, interest, for ten years, after which the production is per annum from $15,000 to $20,000.

In 1879, the last half-year's return of export of sago in Sarawak was 6,695 tons of manufactured sago, equal to $419,959. Tapioca is also much cultivated, and capable of great development; this also is a name very familiar in the list of simple puddings amongst us. So that, apart from the supply of many natural products acceptable to the lower animal creature, there is in Borneo a marvellous pply for man in his advanced civilised state.

Sport and Natural History.

When we think of what South Africa was when Gordon Cumming first began his murderous sport amongst every kind of wild animal, which seemed to swarm in that part—from burly hippopotamus to dainty gazelle, and of the bison of America, and the elk of Sweden, and Ceylon generally, we cannot put forward Borneo as a grand field for large game. Borneo has the elephant, rhinoceros, wild cattle, Sambur deer, small roe deer, crowds of pigs—very tusky indeed, some bears, and, although not quite one's idea of game—the orangutan, and certainly, no one who has watched the small species of these latter in their domestic life and habits, or has ever shot a monkey, would look upon an ourangutan as game. Let us, then, notice the larger classes.

First, the elephants have been but little disturbed as yet, from the immense tracts of unexplored country and dense jungle. They have continued their retired life, we may say, peacefully. Very few have been shot, and explosive bullets and big-bore weapons are for them, comparatively, things of the future. The explorer, Frank Hatton, shot at and wounded one when he met with his sad and fatal accident, and a monument at Sandakan reminds the visitor of the good work he achieved. Still, the elephants are there, and the first sight of elephant spoor in the jungle is a genuine excitement. This we found on our way to the Caves of Madai, in Darvel Bay—not one, but several, and the natives who were with us thoroughly entered into the spirit of the discovery. The spoor we measured, and it gave 18 inches diameter, a circumference which proved that the elephants of Borneo are not pigmies. Near this same spot a very interesting occurrence is related by Mr. Pryor, whom we met at Singapore. A number of native birds' nest collectors were on their way up to Madai, following the very contracted jungle track, in line, labouring with their heavy loads of rattan ladders, nest-forks, provisions, and general gear, when a tusker rushed through the line. The first scene must have been really amusing; fear on both sides, natives and elephants equally, seems to have been the chief characteristictic of this first stage of the event. The natives could not make much of a bolt, from the density of the jungle on both sides, but they dropped everything; the elephant was equally astonished, stared, and rushed off at the top of his speed, knocking over several in his hurry to retire. Mr. Pryer, a short distance

behind, was surprised as he came up to find all his followers, as he described them, up in trees like a flock of large monkeys. Another time, camping out under a lean-to, he was awakened by an elephant grumbling away to himself within a few yards of his head. This was really an anxious moment, Mr. Pryer roused his men, who got their rifles and they fired, but with a most unexpected result, for the elephant remained perfectly quiet, not a sound from that individual, but a voice from above, that of an orangutan; a pause of but a moment, and down came—with a tremendous crash—one of the large forest trees. This "Jumbo" did not approve of, so away he went, trumpeting loudly and wildly, and evidently disgusted with the reception he had met with at the hands of these new invaders. This falling of trees is easily accounted for, particularly as associated with the orang-utans; for, whether, from pleasure or anger, they delight in making a tree top sway backwards and forwards, and many old decayed jungle giants are ready to fall on the least provocation. The fresh tracks of about twenty elephants were found close by. Darwin maintains that the very large animals consume little vegetable food in proportion to their size, but when the natives find their tapioca plantations being destroyed, and the Manilla hemp banana (*Musa textilis*), completely eaten, they then wish their appetites were smaller.

We did not come across a rhinoceros, although he is less timid than his larger brother, the elephant. Mr. Pryer, the resident of the east coast, gives us another experience, which is of all the greater interest, as coming from one personally known. More than once a rhinoceros has strayed within the suburban line of Sandakan. Once getting into a garden he devoured all the melons; that was peaceful pastime, but the next incident was real business. Sheer curiosity led one of the animals to push his way into a chicken-house, and when the native went with a light to see what was the matter, the intruder rushed through the other side, carrying part of the structure with him. Still one more. This time the rhinoceros came in from the forest, and trotted past Mr. Pryer's house into Sandakan, in the middle of the night, and not understanding or liking the lights, came back and went down a gully at the back of the houses, not 70 yards off, making a great noise, whilst Mr. Pryer and his wife stood on the verandah with a rifle, in case he charged the bungalow.

There are wild cattle on the east coast, and in the north buffaloes seem fairly abundant, and numerous about Kina Batagan. Mr. Pryer mentions stalking a herd at this place, and his intense admiration for a fine old bull, who stood on a mound lashing his tail, and so engrossed his attention that he did not shoot him.

Sambur Deer seem very evenly distributed over British North Borneo, as also are the kajans, or roe deer, with their delicate horns, with long pedicle, covered with hair up to the burr about three or four inches. This roe is generally known as *Cervulus muntjac*. We regretted not seeing the little mouse deer, which are so very delicate, and very difficult to get safely over to this country.

Wild Pig.—We now arrive at the wild pig—a most persevering and continuous visitor, with a strong *penchant* for pineapples and sago, and other good things. These ruthless invaders are hunted at at Sandakan with a pack of little native dogs, and sometimes a dozen will be the result of a good day's sport. Average specimens of Sandakan tusks are shown here from root to tip, following the outer arc of the canine, about eight and a half inches; but it seems generally allowed that the biggest boars have not the largest tusks. One morning at day break we were awoke when sleeping in a bungalow, on the hill at the back of Sandakan, near Dr. Walker's, by low long chorus of chattering monkeys, and when we got up we found all the pine-apples in the garden had been destroyed by the wild pig of the forest. It takes a very strong fence to keep them out. Coming up on the previous evening we had noticed the slots of some of these fellows quite close to the bungalow.

Orangutans.—Of these there are two kinds, large and small. Here is a photograph of a large one, a dreadful looking creature, shot by Mr. W. R. J. Dunlop, March, 1886, and photographed by E. Abrahamson. It stood 4 ft. 10 in. high, with two black collops or pieces of flesh hanging down over its face. When this creature distends his throat, which he does when excited, he looks a demon of ugliness and ferocity. The smaller ones are most gentle and tame, allowed on all sides to be perfectly free from vice, and full of affection, without any of the mischievous pranks of the monkey tribes. Zachariah and his wife, whom we saw at Mr. Davis's, at Kudat, were really delightful; we watched them some time, and the tender attentions of Zachariah to his wife were very touching. The way in which he

caught a butterfly between his second and third finger was most elegant.

Bears.—These we will pass over, mentioning only that they are small, scarce, and known as *Helarctos euryspilus;* with large claws, and about the size of a retriever.

Crocodiles.—Now for the crocodiles, the unwieldly but ferocious crocodiles on the East Coast. On the Kina Batangan River the natives of one village, Sebongan, positively left the place on account of these creatures, so many were carried off by them, knocked out of canoes, and seized when bathing or getting water. On the Labuk was a place where passing canoes were frequently attacked, and on one occasion two crocodiles made a simultaneous attack on a canoe containing five men, and each crocodile bagged his man. The cure is the Keelong or bamboo fish-stakes, already described. A Dutch friend, Freidrick Waitz, showed me a very interesting little collection which he took out of the stomach of a crocodile he had shot. It was as follows:—Five silver rings, as worn by native women, one small brass bell as worn by goats, and eleven small stones about ½ and ¾ inch long. The length of the crocodile was 15 feet. No alligators here; and as the difference between alligator and crocodile is not generally known, I may notice that crocodiles have the fourth lower tooth passed into a notch at the lateral edge of upper jaw. Alligator's fourth lower tooth is received in a pit in the upper jaw when the mouth is closed; and a third kind of *Crocodilia gharials*—there are some in Borneo—only eat fish.

We must now refer to crocodiles as an item of food. The Sundyaks (Dusuns of the east coast) keep the supply of crocodiles down by eating them, and reports tend to show that their larder is gradually getting empty. They positively fish for them in the following mode. A dead monkey is a deadly bait for this sport. Tie the bait firm bound on a stick; all along the stick at intervals are tied lengths of fishing line. These are brought together 7 or 8 feet off to the end of a rattan 70 or 80 feet in length. The bait is then thrown into the river at a likely place, the other end of the rattan slightly secured to an overhanging branch. The crocodile is thus able to take his bait and retire for his meal, the stick being a mere matter of detail. The fisherman, or rather sportsman, coming the next morning, finds his rattan gone, and then searches along the river until he finds it floating on the stream; when found, it indicates that the crocodile is down below chewing his monkey-cud. The rattan is seized, a sharp jerk draws the stick "athwart ship" in the interior of the crocodile. The rattan is hauled on shore as quickly as possible, and then the struggle commences; and should he be a twelve-footer, they have a job to play him. It takes a good many men and strong tackle to haul him on shore. Unfortunately, no particulars were given as to the prime cut of the quarry, except that the tail is best, nor how best to serve it; but crocodile steak does not sound inviting in any form. Having eaten dog and whale myself, circumstances might make even crocodile acceptable.

Mr. Buck told me some further details of catching these creatures. The professional sportsmen, when they first get one on the line, address him with different titles, a relic of the worship of the ancient Egyptians, as they believe the reptiles to have grades and relative ranks. They begin by "prince," "rajah," "pangeran," &c., and gradually go down the scale until he is landed, when they call him very hard names at the finish. Mr. Buck also told me that he saw one hauled out once which had an old cross-piece sticking out through his side, and the skin had healed round it. Evidently crocodiles do not profit by experience.

Keelongs or Fish Stakes.—The East Coast of North Borneo simply swarms with fish, principally owing to the wide extent of moderately shallow water, and the islands. There is a great variety of fish and there are numerous methods of capture. The wholesale process of capture is a most interesting and successful arrangement, founded on the principle of our wire mouse-trap. It is called a "Keelong," or fishing stakes. A bamboo barrier extends from the shore to the required distance out to sea. The fish skirt along this, and are so conducted into two outer chambers, till in time they arrive at the end compartment. When once inside the outer chamber there is little chance of escape, the sides curling inwards in a heart shape; the "bitter end" is generally round, and some nine feet across.

The keelong is made of split bamboo driven into the sand, admirably lashed together with split rattan; the total length of the split bamboo poles is about 14 or 15 feet. Low tide is the period of capture, natives paddling from the shore frighten the fish into the end compartment, and then close the narrow entrance. It is a wonderful sight, from the slender bamboo scaffolding which surrounds

the inner chambers, to look down on the "bag" below; the water crowded with all kinds, sorts, and sizes of fish. The next thing is to lash a loose piece of keelong, or bamboo matting, blind or screen, kept for the purpose, to the inside of the chamber, and being unfolded gradually, the fish are driven into a central fold of it until there is almost a solid heap of them; then they are taken out and the canvas filled. Three to five piculs* a day is an average for one keelong. So far for the fishing department of the keelong, which has another very sportive function, namely, that of crocodile captor. Should a crocodile be ever in the neighbourhood of a keelong he is bound to be safely in it in a day or two. At first this seems surprising, when we consider how slight the bamboo fabric really is, but the elastic heart-shape does it. However large the crocodile he cannot put out his strength, especially when partly curled round, and a bullet from above closes his career. The other usual Chinese methods of fishing are used. Mullet abounds, sardines are very plentiful. For the former, the mullet, the twenty-foot dip net is generally successfully tried, and dropped when the shoal passes.

Tobacco.

The primary products and leading features for the success of the colony were certainly:—Timber, the cultivation of the soil, developing the larger production—sago, fibre plants, such as *Musa textilis*, coffee, tea, and sugar, with hopes of making tobacco a leading feature later on. Within a very recent period that later on seems almost to have arrived, if one may judge from the capital so readily subscribed by leading men in Hong-kong and Singapore—men who, being close at hand, with most reliable local knowledge, must be the best judges of what will lead to prosperity and rapid commercial progress — Sumatra tobacco especially. The growth of Deli is a good criterion in this matter, and I think a few details will not be unacceptable on this point.

The Darvel Bay tobacco estates have produced excellent tobacco, in the form of the particularly thin silk leaf, so valuable for cigar wrappers, and it now appears that the production extends over two degrees of latitude, and the districts are favoured by navigable rivers to good harbours; a matter of great importance in the absence of roads. To the practical mind, the fact of 350,000 acres of land having been taken up during the past year, and the capital subscribed, prove that people are in earnest; and this ready supply of capital emanates from the people most closely connected with what we may call the trade—men of experience, local knowledge, and the latest information. Our own two British colonies, Singapore and Hongkong, which are so close to Borneo, as neighbours, evince the greatest interest in her welfare, and instead of exhibiting a little sly tinge of jealousy of their young growing sister, they put forth their hand to help and rear her, in a way which we hope will result in mutual benefit; and there are now fifteen companies in organisation, and large tracts are being taken for coffee at the south of Marudu Bay, on the Benkoka River, and on the East Coast Provinces, on the Kinabatangar River.

Gold of Sagamas River (Lat. 5° 50′ N.) we must leave for future development, but specimens have been sent to London, and Mr. Sketchley and Mr. Allard, the explorers, have returned in good health, after an absence of several months, which says much, I think, for the climate of Borneo.

There is another important point to consider in a paper on Borneo—the machinery for its development, apart from natural workings of the season. The capital, that most important, motive power, is already plentiful; next, the manual labour.

Colonisation may be thus diagnosed; the English select and administer by individual energy and intelligence; the natives are not inclined to work; so the Malays, or Karnakas, and John Chinamen coolies come; but John Chinaman is the steady worker who plods on and helps himself and his neighbours, and gets more help if required, through his mysterious sort of secret society, which is good up to a certain point, short of politics; and more, the Chinamen are good citizens, they are always at work, steadily progressing and adding to the revenue indirectly, so that the old idea that the Chinaman would never leave his native land belongs to the past—in fact they flood all colonies. There is more emigration from China than from any country in the world. Look at Singapore. Although so near home, the Chinese will not go home when they have made a fortune, and why? They fear being blackmailed, and having tasted of British rule and British freedom, like it and stick to it.

* Chinese picul 133½ pounds.

Edible Birds' Nests.

As the Chinese are the great consumers of edible birds' nests, one would naturally think that when the coolies or Chinese emigrants had come so far, and got so near birds' nests, that they would do a little bird's nesting themselves, but they do not. It is a laborious, risky sport, so John Chinaman keeps a store, and takes the money earned by the native bird-nester. The sure sign in this year of grace that a Chinaman is doing good business is that he wears an English billycock on his head, with his tail coiled up.

The nest caves are Gomanton, Sandakan Head, Madai, and other localities—Mantanani Islands, for instance. The bird is a beautiful swallow or swiftlet, and the caves of limestone are populated on the "Box and Cox" system. The natural inhabitant is the swallow, who is out on business all day and returns at night; and the bats, who are at home all day, are out all night. So much has been written about these birds' nests and swallows that it seems superfluous to refer to them, but having been in the caves of utter darkness, and heard the weird cry of the birds themselves, I may say something about them. The bird itself is a small swiftlet of the genus *Callocalia*, and it would appear that the darker the caves the better they like them. The nests are of two kinds, the white and transparent, and the inferior or black nest. The blackness of the latter is produced by small fluffy feathers being worked in with the gelatinous salivary substance of which the nest is formed. The probability is that the white nests are made by tidy birds, and the more slovenly ones by untidy birds.

The Chinese are the edible bird nest fanciers, giving high prices for the best qualities for their choicest soups. To produce something very choice in this way, 120 grams would be used for one litre of soup, and the value of the nests is about 2,500 dollars per picul ($133\frac{1}{3}$ lbs.) for the first quality, 1,500 for the second quality, and 1,000 dollars for the third.

In some parts of China as much as £9 sterling has been paid for a cutty (about $1\frac{1}{4}$ lb.) of these nests, and the quantity annually exported to China from the Indian Archipelago is estimated at about 242,000 lbs. weight of nests. Apart from the delicacy and general pleasant qualities of birds' nest soup, the Chinese regard it as a general restorative, and a medicinal factotum, whether for consumption or opium smokers.

The nests themselves are most delicate little things, and one would think there was hardly room for the swiftlet itself. They are built against the rock, about a spread of $2\frac{1}{4}$ in. to $2\frac{1}{2}$ in., and standing out about $1\frac{3}{4}$ in. The natives exercise great ingenuity and perseveronce in getting them. They have rattan ladders of immense length, and bamboo scaffolding, and they finally get them with a long bamboo, split at the end into four prongs, two pieces across to prevent them closing, and bound with rattan to keep it from splitting farther. Below this is fixed a candle, to see the nest and where to take it. The nests are taken about twice a year.

Weapons.

The true weapons of Borneo are the parang, spear, and tumbeloosow, used by the Bajaus, or sea gypsies, the water wanderers, wild roving people, very like pirates. The tumbeloosow is a long light cane of bamboo, with a sharp wooden spike: they can throw this about two to three score yards. Sumpitan, or blow-pipe, with poisoned arrows, used by Dusuns and Sundyaks. The Dyaks are considered the aboriginals of Borneo.

The parang ilang is the characteristic weapon. The blade is 22 inches, and has this peculiarity, that it is concave on the left side, and convex on the other. The width of blade at the handle is $\frac{3}{4}$ inch, and three-fourths up $1\frac{3}{4}$ inch wide; the very beautiful ornamentation is on the convex or right side only, and brass inlaying extends $7\frac{1}{2}$ inches; the handle is 6 inches, $2\frac{1}{4}$ inches sambur horn, $3\frac{1}{2}$ inches of rattan dyed black; for 7 inches from end of blade the back of it has open work in the blade; total length of weapon 28 inches. The carving ot the horn is very curious and mysterious; one large tuft of hair comes out of the pommel, and the down prong has another bunch of hair, black, white, and red being the varied colours of the tufts. On the back of the wooden scabbard, which is rudely but very beautifully carved, is a second sheath covered with bead work, this carries the betel knife; and when a native parts with his parang, he invariably keeps, or tries to keep, his betel knife; this is a very curious little weapon; blade 3 inches long, $\frac{3}{4}$ inch widest part, also concave and convex, but the handle quite round, $1\frac{3}{4}$ in. in circumference, is 14 in. long, the object being to pass the long handle under the right elbow, and so get leverage with the hand close to the blade to strip the rattan for plaiting; and it is also used against an enemy on occasion. The

sheath of the parang is tufted over with human hair, souvenirs of victims, and the weapon now shown has the following history. This parang ilang belonged to Captain de Fontaine, who died of the wounds he received at the Kawang Amok; and he got it from the son of an old Dyak who who took seventeen heads with it, and who was at first one of Rajah Brooke's greatest enemies, but afterwards he came round, and used to be one of the best men in the Sarawak irregular forces.

The Biliong, or *Adze*.—The native adze is an implement of the greatest interest, and will soon become historical. At the first glance one would think it was a stone implement, hafted in the usual manner. What they achieve with this instrument in forest work is really surprising. It does not look fit for cutting down trees three or four feet in diameter; still, with skill and perseverance, this is done, and the precision with which each stroke is followed is something to behold and admire. As the blade lines with the handle it is an axe, but the native, for agricultural purposes, turns it round and uses it as a hoe. The rattan plaiting is very good, and it being so well worn by the hand adds to its interest as a specimen, and the skin of the orangutan on the top gives a thoroughly wild finish to it.

	Inches.
Width of blade	3
Length of shaft	17
Diameter ,, ...	$\frac{9}{16}$
Length of thick handle for the left hand	5
Diameter ,, ,, ,,	$1\frac{1}{2}$
Length of head over all	10

Population.

The Dyaks are the inland aboriginal race, and retain their original character by their notoriety for head hunting. The densest population is on the west coast, from the fact that the east has suffered so much from pirates, Sooloos, and Illanuns, by sea, and in the rear from the head-hunters by land. The true Dyak is a terrible fellow for this head hunting, and only a few years ago many houses in the west were ornamented with heads hung round them, and sometimes village feuds added to their number. The man who took heads generally had a tattoo mark for each one on the arm, and was considered brave—very brave—even if he took the head of a woman, for that was considered as good as a man's. The possession of a head is a certain method to ingratiate oneself with the fair sex; and on one occasion Mr. Everett went up the Rajang River, and made the men give up 30 heads, which he brought down, all lashed on to the stanchions of his steam-launch.

On the east coast abound the sea gypsies, or Bajaus, and inland are the Booloodoopies, who are described as a curious people, with strangely Circassian features—not Mongolian, but with bridges to their noses, and very round eyes. They are gentle people, and, as the possessors of the richest bird's-nest caves of Gomanton and Madai, are comparatively well off.

In Darvel Bay there are some of a tribe once strong—the Sabahans. Some remain yet heathen, and would practice their old customs of human sacrifice if they dared. In some of the bird's nest caves their mouldering coffins, grotesquely carved in good Bilian wood, still remain. The Dusuns are the people of the interior and west coast, and are closely allied to the Dyaks, so are called Dyaks. In the interior they live 20 or more families together; in that case the long house is called a "benatong." There are in the interior so many distinct tribes speaking different dialects and languages, that it is impossible to separate them in so general a paper as this. I believe the true Dyaks come from Sarawak and Atchinde.

The Dusuns and Sundyaks are much given to dancing, and will dance pretty well all night to a music of very rough and original character. The Dusun dances slowly, and keeps on even till daybreak. The Bajan, a wilder and more excitable creature, goes bounding about until nearly exhausted. On these occasions their dress is certainly striking, a skin over the shoulders, with a hole like that of a pouch for the head and neck to pass through, terminates down the back with the tail feathers of the hornbill, then feathers in the hair; and, curious to relate, as these good people wear such very scanty garments, they have a great horror of sitting on anything damp, and for that purpose they carry about with them a very cunningly wrought seat, of shield-like shape, made of split rattan. In their dances they use their long narrow shields, inlaid with cowrie shells, and profusely decorated with human hair. Their parangs are swung about, and the whole thing is wild in the extreme.

We must notice their bamboo work, the ornamentation of which is remarkably bold and good. The Dyaks smoke cigarettes, the Dusun and others pipes. We will now look at the pipes, tobacco-boxes, Chinese cases, and the very delicate little wire for the love-sick

swains, who play upon the Jews' harp kind of instrument.

First, the pipe, a piece of bamboo 14 inches long, with a joint at the end, diameter of bamboo $1\frac{5}{8}$ in. in diameter. The mouthpiece end, rather large certainly, is bound over with brass wire, and the tube filled up with grass to prevent too much draught, and this is very necessary, as the fill of tobacco at the other end is only the size of the kernel of a Barcelona nut. The bowl of bilian, pretty in design, is placed at the joint, and a small hole through it carries the tobacco smoke up the bamboo stem. Strong brass wire runs down each side, so that the pipe may be carried with the wire inside the waist-belt, and the pipe outside. The tobacco case is sometimes attached to the bowl end of the pipe; in other cases, it is worn separately from the girdle.

The Jews'-harp-like instrument case is really an elegant thing, with delicate patterns; this also is small bamboo, $\frac{10}{16}$th inch in diameter. The instrument is 9 in. total length, being composed of a broad loop $1\frac{3}{4}$ in. long, a thin piece of brass, with a long tongue, $2\frac{1}{2}$ in. long, for the vibrations and the rest-string, with a toggle at each end to haul it taut. This instrument is supposed to be effective when the musician is in love, and etiquette necessitates his performing a solo in the solitude of the jungle.

The ornamentation of the Chinese cases is always very delicate and beautifully executed. Their household baskets are wonderfully picturesque, and rich in colour, red, black, and yellow, with very little white. Their covers for dishes are worked in similar colours, and exceedingly picturesque.

The men wear very curious hairpins, if we may so call them, flat Sambur deer horn, like a paper-knife, ten inches long, one inch wide in the middle, one end pointed, the other widening to $2\frac{1}{4}$ in., with a bunch of very fine woman's hair as a finish; this worn at the back through a clove-hitch of the wearer's hair or tail.

Boats and Pirate Craft.

Their boats are quite a feature. Of course where the Chinese abound sampans must appear also; but the sea gipsies, or Bajaus, alter not, and there is no doubt that, however unwelcome their approach may have been, still a fleet of these craft bearing down in fine weather with a fair breeze must have been a fine sight.

The Ceylon canoes are the nearest to them, but they, with their very narrow bodies falling in above, have only one outrigger; the Bajaus have two, port and starboard. They vary in length from 50 to 70 feet, and when I first saw a model in the museum at Sandakan, it struck me as a wonder of cadis-fly construction—all legs. The bamboo superstructure is intended to hang on to in bad weather, as there is no down below, and the way in which the outriggers curve up forward to offer the least resistance is very good. About four large paddles are carried for calms.

The natural history must be summed up in a few words of admiration for the beautiful Irena—a king-fisher of exquisitely brilliant blue and black—as representing the small birds, and amongst the larger the horn-bill, the black and white feathers of which are in great favour with all the natives. There are the argus pheasant, with four feet of tail; the fire-back pheasant; the *Lobiophasis Bulweri*, or "Bulwer pheasant," already mentioned as being found on the high land on River Lawas, east of Labuan. It is a plump-looking bird, head and neck of most lovely blue, body black, blue shot, and tail thick, of creamy white colour. The feather ornamentation of the head is a very curious arrangement. There are many beautiful smaller birds, partridge, quail, and thrushes, some of exquisite colour.

After considering the facts which I have had the pleasure of laying before you concerning Borneo, its natural products, and the rapid development of country inland, we may consider that it really is a territory of great promise. The Dutch have the south two-thirds of the island, but the more temperate latitude of British North Borneo is a great advantage to us, and if they had the chance they would be very glad to change. The progress in the last few years has culminated in the encouragement of the companies for tobacco growing. By those who should know most about the merits of the case, it is not likely that Borneo tobacco taken to Rotterdam for the annual sales there would fetch the good price it did last year if it were not a superior article; and it did achieve this great success even to attaining a higher price than the Sumatra tobacco of Deli (lat. 4° N.), which is the stronghold of the Dutchman next to Acheen. To carry out and mature this work, there is out in Borneo an admirable staff of officials, who combine with their natural good English character great experience and local knowledge

At the commencement of this paper mention was made of young colonial plants; now England seems to be a kind of national banyan tree, she stretches forth her branches over the earth, and when her aerial branches find kindly ground they take root, receiving sap from the mother stem, and root and start off again, and many and happy are they who come and sit under the shade of her. In foreign lands, whether in India, where this is most palpably shown, or elsewhere, so long as justice is administered by Englishmen, so long the native feels safe, and his life and property are surely preserved for him. That is no small advantage in governing a large population; and that wholesome influence is felt in British North Borneo.

In conclusion, I think it will make this paper on Borneo more complete if I tell you how I got there. It was my privilege and good fortune to visit Borneo in the *Sunbeam*, 1887, and it would be wanting on my part if I did not avail myself of this opportunity to offer a tribute of respect to the memory of the late Lady Brassey, whose high courage and spontaneous adaptability to the various circumstances of foreign travel were wonderful. And to Lord Brassey also, our appreciation of his navigation of the *Sunbeam* at home and abroad. Three hours passage of the Mallawalle Channel was a great triumph, and the English staff of Sandakan were proud of its having been performed by an English gentleman.

DISCUSSION.

Mr. CROCKER said this paper had a peculiar interest for him, as, through the kindness of Lord and Lady Brassey, he had the good fortune to be a fellow passenger with Mr. Pritchett on the *Sunbeam*, and was able to confirm his first impressions of a country with which he had been connected for twenty-five years; and he was much interested in going again to Sarawak, where he had spent sixteen years, after six years absence. He could quite confirm what Mr. Pritchett had said about Sarawak being a happy example of the good government inaugurated by Sir James Brooke, and successfully carried out by the present Rajah. It was the dream of the old Rajah to obtain the British protectorate; this having been accomplished, no doubt the future of the country was secured. He wished, however, to call special attention to the tobacco planting in North Borneo. One of the objects of the Society was to call attention to any new product likely to be of commercial value, and though it might be said that tobacco was not a new product, yet the kind there grown was new. Practically it had been hitherto a monopoly in the hands of the Dutch, and he remembered, about twenty years ago, soon after he went to the East, the first tobacco sent home from Sumatra, and it was found that its silky nature and fine aroma made it peculiarly well-fitted for covering cigars, and for that purpose it fetched a very high price in Amsterdam. The trade grew very rapidly, and after a few years the imports amounted to one million sterling in value, whilst last year they amounted to two and three-quarters millions from Sumatra alone. Hitherto all attempts to grow this tobacco outside Sumatra had failed, but three or four years ago it was tried in North Borneo, and two years ago it was proved that tobacco, quite equal to that of Sumatra, could be grown there. Directly this became known there was quite a rush of planters to take land, and up to the end of 1888 there had been applications for over 500,000 acres, of which over 100,000 had been taken up, and there were twenty companies formed with an aggregate nominal capital of over one and half million sterling. The idea was to make London the market for this tobacco instead of Amsterdam. Although it had not yet been announced, it was an open secret that the London Chamber of Commerce, which lately offered a prize of fifty guineas for the finest sample of tobacco from any British colony, had awarded it to British North Borneo and to Jamaica—to the latter for its fine smoking qualities, and to the former for its commercial value.

The CHAIRMAN said it was evident from this paper that Mr. Pritchett was a quiet observer, and noticed that which was most worthy of observation. There were no doubt some disadvantages in a tropical climate; neither crocodiles nor elephants were the most pleasant of companions, unless well under control, especially the former, but where there were many Englishmen at work, with Malays under them, he thought crocodiles would soon disappear, either by being eaten or in some other way. What Mr. Crocker had said about the tobacco was quite true; it had been uphill work for eight or ten years, but, according to the French proverb, everything came to him who could wait, and this had proved correct in the present instance. An enormous impetus had been given to the cultivation of tobacco in Borneo, and now, under the British protectorate, with every advantage that good government could secure, the advance would be still more rapid. Europeans could not labour in the fields in any tropical country, and therefore they were always obliged to have recourse to indigenous labour, or to labour from some neighbouring country. Fortunately, Borneo was near China, where there was a superabundance of population, so that any number required would be readily available, all the more so on account of the terrible famine in China, in consequence of which there must be thousands who would gladly go anywhere where there was food. Independently of that, recent legislation, both in America and Australia, was likely to

send back a large number of Chinese who had already found occupation in those countries, and on the whole, there need be no fear of having a too plentiful supply of labour for the next ten years. There could be little doubt that they had heard to-night of a country which at no distant period would take an important place in the commerce of this country. That was the object with which the company was formed originally, and he felt sure they would not be disappointed. It was by no means a light work to undertake—the public work of government by a private company; but our Government, like some others, was not in the habit of taking the initiative where there was any risk, expense, or responsibility. It had been the custom from all time for Englishmen to do that themselves, taking all the risk, and trusting to their fortune and energy to make it answer in the end. Then when there was a colony formed which was capable of producing a revenue, and was important in a national point of view, the Government stepped in and took charge of it. That had been the history of all our colonies, and no doubt would be so in this case. When it had become valuable both strategically and commercially, the Government would be glad to call it a British Colony, or anything else which would make it a part of the British Empire.

Sir PHILIP CUNLIFFE-OWEN, K.C.B., wished, as a member of the Council, to add his testimony to the great value of this paper; and also to say how much he had been interested in it. He had known Mr. Pritchett as an artist, and hereafter the world at large would know him a great deal better than it did at present; for there was being treasured up a series of most remarkable drawings which he had been preparing for many years, and he was quite sure they would be highly appreciated whenever it pleased Her Majesty to allow them to be seen, being, as they were, records of the more important events of her reign. They were much indebted to Mr. Pritchett for what he had told them. His acquaintance with Mr. Pritchett dated from the Indian and Colonial Exhibition, where he took an important part by making sketches and drawings of some of the principal events of that year. They were most fortunate in having as chairman of the evening, Sir Rutherford Alcock, who had done so much to maintain the honour of the English name, and who was always ready to extend his assistance to any worthy object.

The CHAIRMAN then proposed a vote of thanks to Mr. Pritchett, which was carried unanimously and briefly acknowledged.

SIXTEENTH ORDINARY MEETING.

Wednesday, March 27, 1889; SIR FREDERICK BRAMWELL, Bart., D.C.L., F.R.S., Deputy-Chairman of the Council, in he chair.

The following candidates were proposed for election as members of the Society:—

Sandell, Frederic David, 181, Queen Victoria-street, E.C.

Schloss, Leopold, 17, Leinster-gardens, Hyde-park, W.

Lockwood, Crosby, 139, Highbury New-park, N., and 7, Stationers'-hall-court, E.C.

The following candidates were balloted for and duly elected members of the Society:—

Blair, Thomas, Wingerworth Ironworks, near Chesterfield.

France, Chapman, 36, Bristol-road, Edgbaston, Birmingham.

Mann, John Randall, New Barn Cottage, Osborne, Isle of Wight.

Rigby, John, 9, Charlotte-street, Bedford-square, W.C.

Simmons, L. Owen, Wolvesey, Winchester.

The discussion on Professor A. B. W. Kennedy's paper on "The objects and Methods of the Society of Arts' Motor Trials," was resumed.

The CHAIRMAN, in opening the discussion, regretted that he had not the opportunity of hearing Professor Kennedy's paper, but he had since read the paper in the *Journal* of the Society. Of course the paper was certain to be a valuable paper, coming from the source which it did. It was not really a paper on gas or steam-engines, but was on the proper mode of making trials of machines such as these. When one recollected the phases through which this question of engine trials had passed, they might congratulate themselves upon the improvement which had been attained. In the very early days, there were no trials at all. Then afterwards, the trials made were, no doubt, useful in their way, for they were intended to enable us to determine results, but, as a fact, they did not give us any explanation as to the causes of the results, why some succeeded and others failed; nor did they indicate in any way the course that ought to be pursued by persons engaged in the manufacture of machines such as this; nor did they instruct scientific men engaged in the consideration of the science involved in such machines as to what was the direction in which economy might be sought or improvement might be made. Therefore, to a large extent, the trials were barren. The last similar trial for the Royal Agricultural Society, previous to the one at Newcastle, was held several years ago, and then, although he had made provisions for taking samples of the gases from the smoke-boxes of the engines, it was looked upon as a matter of such small importance that he could not get the Council to vote the money necessary to have the samples analysed; consequently they had remained hermetically sealed up

until the present day, and where these samples were now he was not quite certain; the last time he saw them they appeared to be rather good specimens of old gas in bottles. This was some years ago; like other things which are "old in bottle," they were rather crusted—an interesting fact. Now-a-days, not only were there men like Professor Kennedy who were competent to make trials such as these, and to give reasons for the results attained, but the value of such trials was well understood. Professor Kennedy and his colleagues had attained a greater degree of exactitude than had ever been attempted before, and they had a most difficult subject to deal with. They had to consider gas-engines as compared with steam-engines, which opened up a new range of questions; though in the case of the gas-engines the efficiency, or rather want of efficiency, of the boiler is eliminated. On the other hand, these trials were encumbered with the new condition, that of the great regularity required in motors for electric lighting. Although the Royal Agricultural Society's trials had, as a rule, required that the engine should be self-governing, and that no great variation in speed should be allowed, yet self-government in truth meant in these trials only a reasonable and ordinary one, and did not mean such exact regulation as was necessary for engines used as motors for electric lighting. Professor Kennedy and his colleagues, therefore, had had before them greater difficulties than those which usually prevailed in making somewhat similar trials. It appeared to the speaker that the judges had dealt with the various points in an extremely complete and satisfactory manner, and he should be glad to hear from those present who were conversant with these matters further suggestions for these trials in future. He was sure that no one would be more glad to hear of such suggestions than Professor Kennedy himself. He hoped that this would not be the last time the Society of Arts would have trials of this character. As they were aware, the Society had attempted a year ago to have a series, but the response from the manufacturers was not satisfactory; even on the present occasion the Society had brought together an elaborate tribunal, at considerable expense, to try a very small number of exhibits. He hoped that the ice having once been broken in this direction, on future occasions, if the Society repeated the offer, it would be more abundantly responded to. They were all aware that the Society only initiated things of this kind, and that they then turned them over to other bodies to take up, a notable example of that being the Technological Examinations. It was no part of this Society's business to spend any very considerable sum of money on one branch of science. He thought that the Society might, in the near future, repeat the proposition that there should be similar trials to these, and he trusted that the proposition would be more freely responded to. He was under the delusive impression that he was the originator of the balance-sheet mode of stating the performances of engines and boilers, and that it was first done by him in 1877, in reference to a trial of a boiler made by Dr. Russell and himself, but he had heard to his sorrow that Mons. Hirn was before him, and that he had published the idea so long ago as the year 1856. He thought it an extremely satisfactory mode of stating the results obtained, and a mode which must commend itself to them all. When you applied book-keeping to the results of such trials as these, you found you were debtors to an inexorable amount of heat units, and you were bound to give an account of what you had done with them, and uncommonly difficult it was to do so. The horrible item of difference by loss, or unaccounted for, came as a reproach to the book-keeping. Although it was a reproach, it was more honest to know it and to face it, so as to devise means to get rid of it, than it was to hide it altogether, and to say, "I do not care about details and about the results." The Society owed a great deal to Professor Kennedy and to his two colleagues, for having worked at the matter in such a careful way. He had the honour of being one of the Motor Committee; the three judges met the committee and discussed the matter with them, and, having done so, he (the Chairman) said he was very thankful that he was not one of the judges. The matter was further discussed, and the result was that not only the Society of Arts, but the engineering profession owed a deep debt of gratitude to the gentlemen who had undertaken this most onerous duty, and who had, at great loss of time, carried that duty out. He should be glad if they could utilise the evening on the lines laid down by the paper, which embraced the consummation of the objects and methods of the Society of Arts' motor trials. The main object was to ascertain the best engine for driving electrical apparatus. The method of conducting the trials had been clearly set forth by Professor Kennedy, and he should be only too glad if some gentleman could point out any direction in which the trials might be amplified or simplified, so that judges might in future be relieved from the heavy task of determining what they were required to do, which Professor Kennedy and his colleagues had before them on the last occasion.

Mr. W. H. Preece, F.R.S., said he did expect that, at the Society of Arts, he should have been able to have obtained a copy of the report of the judges on the trials made at South Kensington. He found on inquiry that the demand for these had been so great that there was absolutely not a copy left. This he took as an indication of the extreme interest which had been taken in the trials that were conducted. There was no doubt that of late years nothing had been done in the electric lighting world or the engineering world which had attracted so much attention. He was one of the members of the committee who dealt with the subject,

and the object they had before them was rather to follow in the footsteps of the Royal Agricultural Society. No one would disagree with him when he said that nothing in this country had done so much to improve the character of agricultural machinery as the trials inaugurated by the Royal Agricultural Society. They were in hopes that the introduction of trials, such as those which had taken place, would have the same result with regard to the construction of engines for electric lighting purposes. The idea was that we should rather encourage manufacturers to construct engines of a small type to enable isolated installations, country houses in particular, to establish electric lighting without much personal trouble. There were many places in this country where gas was not available. There were many houses in the country where you could not get water power, and in such places a small steam-engine of four or five horse-power would be an immense boon. In other places, where gas existed, there was a question whether gas was better than steam; aud again, owing to a considerable amount of advertisement, there was a question whether petroleum was not likely to be better than either gas or steam. The Council of the Society of Arts, acting on the recommendations of that committee, started these trials, and he was sorry to say they were disappointed in the number, though not in the character of the trials. They were disappointed in the number, because they only succeeded in inducing one steam-engine manufacturer to compete. No petroleum engine manufacturer appeared, and all the engines were rather beyond the dimensions anticipated. The nominal horse-power of the engines were 6, 9, 8, and 10. Although in numbers the result was disappointing, and although the immediate object of the committee was not attained—that is, no one came forward with a class of engine which could be used in a small house—nevertheless, those which came, although they varied from 6 to 10 horse-power, were most admirable. The first point that the trials had established was this—an immense amount of confidence in gas-engines. The trials had brought to light the fact that, from an economical point of view, gas, which was generally supposed to be rather expensive, could compare most favourably with steam. They knew, for instance, that one pound of gas at the average price in London cost about 1d., and the cost of coal was something like a tenth of a penny. He would take it at 20s. a ton, as that was a convenient figure to use. The trial showed that, taking the heat-units developed by a pound of gas and by a pound of coal, the balance was very much in favour of gas; it was somewhere about the ratio of 1·33 to 1. When you utilised these two modes of energy, you found that in the gas-engine you got 22·7 of the total efficiency of the heat energy, while in the steam-engine you got about 11, and in the Paxman engine it was a little over 12. Roughly, the ratio between heat efficiency of steam-engine to gas-engine was about 1 to 2. If you took 1·33 multiplied by 2, and multiplying by the ratio of their efficiency, you got to this, that the cost of steam was to the cost of gas as ·266 was to 2. The cost of steam was about a quarter that of gas. Again, the gas-engine was always ready, you could get to it at a moment's notice. You lit the igniting jet, turned the fly-wheel, and away it went, but with a steam-engine you had to fire, and lose time and labour, besides expending a considerable amount of coal. When you had done work you had to fire down, and the man had to hang about a long time, and the engine lost an immense quantity of heat by radiation, which had to be maintained by coal. The result was, when you compared the cost of power as developed by gas and steam, the difference between the two was not very great, but it was plainly in favour of steam. His house was lighted up by a gas-engine, and having had five years' experience of it, he found that, taking the average of five years for such a house as his own, the cost per horse-power by gas was £10 a year, and for steam it would be about £7 per horse-power per annum, which was a very fair estimate indeed. The cost of gas as against steam was £10 to £7 per horse-power. This would be found to be a very fair relative measurement. Professor Kennedy, in his paper, dealt principally with the scientific aspect of the question, and he pointed out what was perfectly true, that science really meant measurement. Without an absolute system of measurement and proper methods of measurement, it was impossible to arrive at really reliable figures and facts. One of the great merits of these trials had been the beauty as well as the simplicity of the mode of measurement. Nothing more convincing and complete in its way had been shown than the elegant simple brake used. A paper was read on this subject at the Institution of Civil Engineers last year, and the Royal Agricultural Society had carried out, under the direction of the Chairman, at Cardiff and Newcastle, a series of careful tests, but their figures had always been questioned, and their modes criticised. Here, on the other hand, a brake had been used which defied criticism, and he had not heard anyone as yet question the accuracy of the deduction from it. The thing was so simple that anyone could go to any gas engine, or electric motor, and with a spring balance, a few weights, and a little rope, make measurements in horse-power that defied criticism, and carried to those who used it a considerable amount of conviction. The only thing which he objected to was the use of the most abominable unit called a horse-power. Horse-power really meant nothing; it had little to do with a horse at all; it had only to do with Watt, who introduced it. In the electrical profession, where a complete scientific system of measurement had been introduced, they had introduced a unit of power which was called the watt. The unit was not an electrical unit, but a pure mechanical unit.

It was true it originated in a power developed by the electric current under the pressure of what was called the volt, and therefore was connected with electricity, but it was a unit which was known, because it happened to be the 746th part of a horse-power. Horse-power was really 746 watts. The term watt was universally used by electricians. He lived in hopes that the Society of Arts would in the future sound the death knell of horse-power, and speak of power in watts. The term was not very euphonious, because when you came to multiples, and reached 1,000, it was called a kilowatt. There was one fact brought out in the trials to which he wished to draw attention, and that was this. It was a very striking fact that there should be such a variation in the amount of heat rejected in the jacket of the different engines. The Atkinson engine rejected 27 per cent. of the heat developed by the explosion of gas in the jacket water. The Crossley engine rejected 43 per cent. The difference between 27 per cent. and 43 per cent. in the heat rejected in the jacket water was a very striking fact, and it showed there was something in a gas-engine which still required investigation and to be developed. He wished it were possible to look into a cylinder of a gas-engine while it was at work, for they were told by the report that the development of heat was 2,500° Fahr. If you got a temperature of 2,500° Fahr. it must be as nearly white in its light-giving properties as an arc lamp if matter be present. The lamps in that room did not reach 2,000° Fahr.; 970° Fahr. was red temperature. Every substance when it reached 1,000° Fahr. was just red, and as the temperature was increased so the white increased, until at last you got to 1,800° Fahr., at which you got bright incandescence. When you got 2,500° Fahr., you got a very brilliant light indeed. If the interior of a gas cylinder was white through the light emitted, it meant there were substances in the gas which ought not to be there. If you had other materials in the gas rendered incandescent by the temperature, you had something absorbing heat which ought to be out of the gas, and probably you do have substances incandesced which radiate their heat to the jacket, and so the water gets hotter than it ought to be. Why it was that the Atkinson engine had rejected so much less heat he did not know. It might be that the rapidity of action in the cylinder, as well as the smallness of the length of motion to and fro, might account for it. On this point he should like to hear some remarks from Professor Kennedy. The work which the judges had done he was bound to confess would be classical, and he hoped this would only be the commencement of a biennial, triennial, or quinquennial series of trials. If they were continued, the profession would very much benefit. The classical character of the work done by Professor Kennedy and his *confrères* would have the result of stimulating engineers to better work, and when the Society of Arts next made up their mind to have trials, he hoped there would be forty competitors instead of four.

Mr. Frederick Edwards, on being called upon to speak, said he had been connected with some of Professor Kennedy's trials, and had been much struck with the success of his endeavours to obtain exact results on board steamers. After seeiug Professor Kennedy's feed measuring tanks at work, he came to the conclusion that every steamer ought to be provided with them, for he considered it quite as important to be able to measure the feed-water as it was to measure the oil and coal. He regretted to say that, having been abroad, he had not been able to read the paper, and was not prepared, therefore, to discuss it as he should have liked to do.

Mr. H. Davey admired the excellent manner in which the trials had been carried out, and their completeness. The Chairman's remark on the advantage of having a balance of accounts and drawing an analogy between the heat account and the cash account was very forcible, and it had occurred to him that perhaps the analogy might be carried a little further. In the case of the gas-engine they had a substance which was subjected to a very much higher temperature than the substance which was operating in the steam-engine. The purchasing value of the material in the gas-engine was higher than that in the steam-engine. There was the difference between dear and cheap money. The money was dear in the case of the gas-engine. Professor Kennedy had shown that clearly in the paper, when he said that the gas-engine had a theoretical efficiency, that is, assuming a certain temperature of combustion. Assuming from the economical composition of the gas apparatus in the engine the theoretical efficiency was 80 per cent. This he called the purchasing value. In the case of the steam-engine it was only about 20 per cent. Therefore the money was cheap in the case of the steam-engine, and dear in the case of the gas-engine. Following that analogy a little further, they found another advantage arising out of the balance-sheet arrangement. The heat-units required per horse-power in the case of the gas-engine was 12,120. In the case of the steam-engine it was 21,300 units; the gas-engine giving an actual efficiency of 26 per cent., and the steam-engine an efficiency of 59 per cent. If you simply looked at the figures of efficiency as expressed in per-centages, it would lead to a false conclusion if you had no other data to go upon; but fortunately complete data was given in the paper, so that correct conclusions could be drawn. The great advantage derived from carrying out trials in the extremely scientific way in which Professor Kennedy and his colleagues had carried them out was that one was able to form some idea of the direction in which improvement was to be effected. In the gas-engine there were very great losses, and it was the duty of all who were interested

in the development of the gas-engine to see if the loss could not be minimised. Mr. Preece had made out the loss of heat rejected in the jacket water. The late Dr. Siemens paid very considerable attention to this part of the subject, as regards gas-engines, and he proposed instead of surrounding the cylinder with a conducting substance, to place a lining of non-conducting materials. That was a direction in which one might work towards the possible improvement of the gas-engine. As regarded the rejected heat in the exhaust, it was a very small quantity as compared with that rejected in the steam-engine. By the balance-sheet arrangement, one was able to see exactly where the shoe pinched, and in the gas-engine it pinched more in the jacket water than anywhere else. It seemed to him that the gas-engine would have a very limited application for anything like large powers until they could get some method of working gas-engines from a receiver. One obvious method would be to compress the explosive substance into a vessel, and use it in that vessel as steam from a boiler, but that probably would be a very dangerous operation, and an easier mode of manipulation was required before they would be able to work gas-engines so as to be of use for very large powers. He had spent some time in experimenting in the direction of getting air and gas in certain proportions, and compressing them into a vessel, afterwards admitting it from that vessel into a gas-engine cylinder and exploding it. He admitted it into the cylinder in this way. The piston came almost to the end of the cylinder, leaving a very small amount of clearance, as in a case of a steam-engine piston. Gas and air was then admitted behind the piston at a pressure of from 30 to 40 lbs. per square inch. After the piston had moved a certain distance it was cut off, and the gas exploded behind the piston. The experiment, however, was not so successful as to induce him to carry it further, especially as there were other matters in which he was engaged requiring his attention. Professor Kennedy and his colleagues had made the trials exceedingly complete, and he should like to call attention to the analysis of the gases. Mr. Donkin had been proposing a testing station in London, he had heard, for the purpose of testing tubes. He thought if they had a public laboratory to which they could take a fuel to be tested, it would be of advantage, and no doubt such facilities for making scientific experiments would be so largely appreciated, that by and bye there would be not only institutions where gas and fuels could be tested, but where engines might be sent to be tested and thoroughly investigated.

Mr. J. ATKINSON, as one of the competitors, was much gratified with the result of the trial Those trials were of enormous importance to the company he represented. One of the notable features, he thought, of the trials was the excellent brake used. As Mr. Preece observed, no one had raised any objection to it; and he thought credit was due in that respect to Sir Frederick Bramwell, who was one of the originators of it. With regard to the loss in the water-jacket, he thought that the fact that in their engine there was less loss than in any other engines, was owing to the work being done three times as rapidly as by any other engine during the trial. While there was the intense heat, it was evident that the more rapidly they got the work done the better, and hence the loss was much less. The expansion to the original volume in his engine took place in from one-third to one-fourth of the time it did in either of the two other engines, and that was mainly the cause why so little heat was rejected in the water-jacket. He should very much like to see, if he could do so safely, the inside of a gas-engine cylinder when the explosion took place. He had certain theories in connection with what went on inside a gas-engine cylinder, which he did not think had ever been publicly stated before. They had to consider that the work was done in a very short time. There was an enormous temperature, and a transmission of a considerable amount of heat through the walls of the cylinder. That heat had to get into the walls in the first place, and that he considered was the most difficult. Professor Unwin had recently mentioned to him a trial which he had made of condensing steam in cast-iron pipes. He had two pipes, one perfectly plain inside and outside, and the other plain inside, but corrugated outside with a very large amount of cooling surface. They were both put into one tank, and the same pressure of steam turned into them. He found that the plain pipe condensed exactly the same amount of steam which the corrugated pipe did. It was evident from that trial that the limiting resistance was the skin resistance in passing the heat in to begin with. If that was so, they could realise that, when the intense heat took place inside the cylinder, a large portion of that heat was deposited on the skin of the walls of the cylinder, and the work was done so rapidly that, in the falling part of the diagram, a lot of the heat was given back again, although some of it got through the walls of the cylinder. He thought Professor Kennedy would agree with him that there were varying opinions as to what took place inside a cylinder of a gas-engine, and would excuse him in differing from him in thinking that the gas was not so thoroughly burnt in the Atkinson engine as he had mentioned in the report. In his engine there was a richer mixture of gas and air, and no residuum as in the Crossley engine. He did not think it was possible to ignite the charge so that the heat was not developed more rapidly in his cylinder than it was in that of the Crossley engine. If the volume of the contents of the two were compared, it would be found that there was three times the volume in the Crossley engine than there was in his engine. They had a small volume to deal with, and the area of the containing-walls per unit of volume in his engine was more than twice as much as in the Crossley engine. If that was so, the

deposit of heat on the surface was twice as great in his engine as in the Crossley. He got some of it back, he thought, in the continued expansion, but he could not believe that he did not burn the gas as rapidly in his engine as in the Crossley. It might have been that greater compression in the Crossley engine would tend to burn it a little more rapidly, but they must remember there was a large amount of residuum mixed up with the charge, and that must have restrained the ignition. In the trials, they had some evidence as to what effect cooling surface had. In the Griffin engine, which was a double-acting engine, there was a piston-rod in one end of the cylinder and not in the other. It was not a very large surface, but the effect of that piston-rod he found in trial A was that the main pressure at the back of the cylinder was 6 lbs. higher than in the front, in trial B it was 8·7 lbs. higher, and in trial C 14 lbs. higher, which he thought showed the enormous influence of the cooling surface. Mr. Davey had made some remarks as to the purchasing value of the fuel, and his remarks no doubt applied correctly to smaller engines, but they were not limited to getting their gas from a gas company. They had other sources of producing it, such as in a Dowson gas-producer, and he thought the purchasing power of fuel compared favourably with anything that had been done in that direction before.

Mr. DAVEY said his remark was with reference to the higher temperature, he meant the higher the temperature, it represents a higher value in a commercial sense.

Mr. ATKINSON was very sorry that the apparatus for taking the variations of speed during one cycle had not worked efficiently; had it done so, he had no doubt but that Professor Kennedy would not only have shown the power developed less intermittently, but would have reduced the height of the lumps very much. He felt very proud of having made the most economical heat engine of any kind that had ever been made, and he was deeply grateful to the judges and the Society of Arts.

Mr. EMERSON DOWSON said that the report which the judges had made was attracting attention, not only in this but in other countries, and he had received letters from friends in Germany and France which spoke of it in the highest terms. It was very difficult to suggest any improvements in the methods adopted at the trials; they were so complete that they really left very little to comment upon. He thought the only matter for regret was, that no means were adapted for measuring the quantity of air used. Had this been done it would probably have thrown light upon the question raised in the report whether or not there was complete combustion in the Atkinson engine. Of course it was extremely difficult to trace what was going on in the cylinder of a gas engine, but the judges would have been assisted if they had known how much air entered the cylinder at the same time that a measured quantity of gas was going in.

The CHAIRMAN said that in the Newcastle trials of the Royal Agricultural Society, attempts had been made by him to see if they could find any meter of sufficient size to effect this, but they were obliged to give it up.

Mr. EMERSON DOWSON quite appreciated the difficulty in doing so, but it had occurred to him that it might be done by a holder, or other means. The diagram showing the intervals between the impulses in the different engines might not be a very accurate one, but, at the same time, it brought home to them how much more uniform the speed of the steam-engine than of the gas-engine; and one could realise how very important it was that the long intervals between the impulses in the gas-engine should be shortened if possible. Up till now gas-engines had been used chiefly for comparatively small powers compared with steam-engines; but when larger gas-engines are made, as they certainly will be, it would be essential that the intervals between the impulses should be shortened, for several reasons. One reason was, that there should be greater uniformity of speed; another was, that the explosive charge should be reduced, so as to lessen the strains on the engine. An engine working on a cycle in which a charge of gas is taken in at every fourth stroke only, the charge must necessarily be strong enough to drive the engine and its load for four strokes; consequently, when the charge was fired, a tremendous shock was brought to bear upon the engine, and in dealing with large engines he felt certain that that would have have to be modified, more particularly as a means of reducing the first cost of the engine. With regard to the noise from the exhaust, that was also a point which in large engines was of great importance. There were means of dealing with it by turning the exhaust products into a pit containing small pieces of brick or other material, which deaden the noise very materially, but with heavy explosions this could not be relied on altogether. Then there was the question of the temperature of the exhaust products, which not only represented so much loss, but in some cases would be a source of danger. Looking ahead to the time when an engine of, say, 100 horse-power was made, these points would have to be taken seriously into account. It had been proved that they could now work a gas-engine with cheap fuel gas, with a consumption of coal under half of that required for the best steam-engine. Every endeavour should, therefore be made to get in the right direction, so as to cheapen the cost of construction as much as possible, and data such as those given in the report now before the meeting would be of the greatest service to those who were at work upon gas-engines. Mr.

Davey had mentioned the possibility of lining the cylinder with a non-conducting material. He thought one might at once say that that would not be practicable, because the material would get heated, and there would be pre-ignitions and false explosions in the cylinder which would render it quite impossible to control its proper working.

Mr. Druitt Halpin thought it a pity that there had not been more engines entered in the competition. In the report of the judges they had started with the premiss that they tried to assimilate the trials as much as possible to those carried on by the Royal Agricultural Society. He thought in that matter they hardly did themselves justice, because the way in which the trials had been carried out left little to be desired as to accuracy in the instruments and measurements. They had adopted indicators which were above suspicion, coupled very correctly, and as to the brake, that was also very much in advance of anything which was used at Newcastle, and was not open to any criticism. There was one point as to the results given by the judges on which he could not agree. The figure, roughly given, was, he believed, 83 or 85 per cent. of the total work done by the brake taken up by the water which cooled it. That calculation was made on the assumption of a certain quantity of water passing into the brake at a temperature of 60°, and leaving it at a temperature of 212°. He thought it was an error to suppose that the final temperature was so high. He thought that the water evaporated at a very much lower temperature, from the simple fact that the wheel was going round practically 2,000 feet a minute; and if they had a strong current of 2,000, something must be allowed for that, and he thought the temperature could not have been nearly so high. He had made measurements with regard to that himself, which supported his view. With regard to the brake, the judges had inferred that they had not the means of determining more accurately the tail-rope to pull round the balance. He thought it was a great pity that these trials had not been made perfect by the use of a Moscrop indicator, an instrument which was now beyond the experimental stage. One benefit which would have been derived from the Moscrop recorder, would have been to have ascertained the speed. The apparatus which was used was no doubt a most beautiful one, but unfortunately it failed. By the Moscrop recorder he had records running over fifteen to twenty hours, where they could distinctly read one-sixth of one per cent. above and below, or a total of one-third per cent. variation in a sixteen hours' run. Another great advantage with the Moscrop recorder was determining the radiation, as was done at Newcastle by taking the falling temperatures autographically. It was a great pity that, in the trial of the steam-engine, the quantity of heat lost by radiation was not recorded. Many members were aware that the Council of the Institute of Mechanical Engineers had taken great pains to get up data as to the results produced by the use of steam-jackets; and if those could have been added, they would have been simply invaluable. He also regretted to find that in these trials no mention was made of the boiler beyond some temperatures. They might have obtained a great deal of information as to what the proportion and dimensions of this boiler was which gave these results. The only figures by which they could follow the results were very curious, and showed that, in the first trial at full power, the temperature of the steam in the boiler was 28·93° higher than the gases, and in the second trial 78·5° higher. This was produced by the use of a coil in the chimney in addition to the more usual feed-heater by which the feed was heated by the steam. Information how far coil-piping in an engine of this size could be used he thought would be very valuable, and he should have liked some expression of opinion from the judges on that point. Mr. Atkinson referred to some experiments of Professor Unwin as to the transmission of heat through pipes. He happened to know something about that. Mr. Atkinson's figures were quite right as to the transmission of heat being equal, but that was only one part of the statement. Under a certain set of circumstances, the transmission was equal, and under another set of circumstances, which was the set of circumstances he wanted to investigate, namely, what the transmission would be in the case of steam-jackets provided by ribs of that kind, he found that if in plain pipes the transmission was one in a unit of time, in ribbed pipes it was 3·28. The chairman had spoken as to the endeavour at Newcastle to procure a meter to measure the air entering into the fire-box. He had tried the same thing himself in another way, but the trial failed, though for a totally different reason.

Mr. Anson asked whether it was not possible to have the same apparatus for measuring the quantity of air as was used in a blast furnace, where the amount of nitrogen in the effluent gases was estimated. One speaker had referred to the great shock which would take place if gas-engines were made on a larger scale, but he would ask whether the Worthington engine did not set an example in that direction, where arrangements for storing up a part of the power in an air receiver were adopted, somewhat in the same way as in the Griffin engine, using part of the power in compressing the charge, which was done at the opposite end of the engine to that at which the explosion took place.

The Chairman, before calling on Professor Kennedy to reply, said he must disclaim being the author of the brake used on this occasion. It was true he had something to do with the trials carried out on the banks of the Nile with a straw-burning engine, and might have had something to do with arranging the details of the brake, but the primary

idea was due to one of Messrs. Ransome's foremen or workmen. He should like to read a few lines from the Report of the Royal Agricultural Society at Cardiff meeting in 1883. One of the two reporters said:—"'A barrister lately said to the same writer of this report, 'You surely do not mean to tell me that you do not know what a horse-power is—you, that have been a mechanical engineer all your life!' The answer given was, 'Indeed I do not, there is a difficulty in the outset, what sort of horse-power do you mean?' 'Why I mean a horse-power.' 'I know you do, but there are five kinds of horse-power.' 'Five kinds! impossible, it can't be.' 'But there are, I will give you the names and the nature of them:—(1.) The real horse-power, the power of a horse, estimated to lift 22,000 lbs. one foot high per minute. (2.) That which in James Watt's time was called the nominal horse-power, a horse-power of 33,000 lbs. raised 1 foot high per minute, which power he gave all his early engines, so that the purchaser, having one and a-half times the power of a good horse, should not be in a position to complain of the engine as inadequate. This term nominal is now commonly confounded with the commercial horse-power, and the name, theoretical horse-power, is substituted to represent that which was received as the scientific horse-power of 33,000 foot-pounds. (3.) The gross indicated horse-power. This is the whole power developed on the piston of the engine, without any deduction for friction, which power, divided by 33,000, gives the gross indicated horse-power. (4.) The nett indicated horse-power. This is the same as the foregoing, minus a certain allowance for friction. (5.) The commercial, or, as it is now frequently called, the nominal horse-power. This is a horse-power about which no two persons can agree.'"

Mr. PREECE thought the Chairman had just given five very admirable reasons why the term "horse-power" should be abandoned.

Professor KENNEDY said he had to thank Sir Frederick Bramwell and the members present very much for the kind reception given to his paper, and, on behalf of himself and his colleagues, could heartily say that they were very happy that the work done in connection with these trials had on the whole given so much satisfaction. Coming to what had been said during the evening, he might say that, as far as his personal knowledge of the brake was concerned, it was certainly Sir Frederick Bramwell's brake. The point raised by Mr. Preece as to the heat rejected in the jacket water was an extremely difficult one. It came out something like this—the engine had to get rid of a certain quantity of heat, namely, all that it did not turn into work in some way or other, and practically this had all to go away either in the jacket water or in the exhaust. He took it that how much went in the jacket water and how much in the exhaust depended very much on the time allowed for it. The two quantities added together came to something like the same in all cases, roughly speaking. In Mr. Atkinson's engine the explosive stroke occupied about 1-9th of a second, in the Griffin engine a little under 1-7th, and in the Otto a little less than 1-5th, and those three figures corresponded very reasonably to the proportion of heat rejected in the jacket water. It looked very much, therefore, as if the quantity of heat taken up by that water corresponded roughly to the time which the gases remained in contact with the cylinder walls while expanding, but how far that was a completely accurate statement he could not say. It was very difficult to differ from a a man like Mr. Atkinson, who had worked so carefully on the matter, but he thought that had a good deal to do with the fact, for he still believed it to be a fact that, in his engine, the whole heat of combustion was not got out of the gases in time to be utilised. Still, that must remain to a certain extent a matter of opinion. He believed Mr. Dugald Clarke said he had fitted a window on to a gas-engine cylinder, and seen the white flame inside; but he had never done that himself. Mr. Dowson had referred to the measurement of air; but there was one difficulty, even if you could get a meter large enough, namely, that in the Griffin engine there was a scavenger charge, so that with that engine, at any rate, the measure of air would have taught nothing. But it was a very great difficulty to measure the air at all for engines as large as these. What measurements they did obtain were by estimation from the nitrogen, after the analysis of the gases. If they could only measure the quantity of air, and also the temperature, everything would have been done to make the gas-engine trials complete; and he thought he saw the way to measure the temperature in the future, but not the air. Several points had been raised by Mr. Halpin, one being the evaporation of the water in the brake; and he said he had made definite measurements, whilst those made in these trials were not so, the quantity only being given approximately, and Mr. Halpin was very probably right in saying that it was too high. He (Professor Kennedy) did not understand, however, that the Moscrop indicator would give the variations of speed within one revolution, which was what they had attempted to get. It was also mentioned that the dimensions of the boiler were not given in the report; this he regretted very much, but it was a point which got overlooked in the division of labour between the judges. All the dimensions had been in the hands of Mr. Trueman Wood for some time, and they would appear in the reprinted report, together with several other additional matters which were not quite clear, and on which inquiry had been made. The surface of the feed-heating coil was about seventeen square feet, and it so happened that when worked out the mean rate of transmission of heat through that was just about the same as the mean rate of transmission through the boiler. It did not, therefore, appear

so remarkable as he had at first thought it that the feed coil worked so well. He must take exception to one remark of Mr. Halpin's about the measurement of feed-water on board ship, for he had made many such measurements, and found no difficulty in it at all. If the weather was very stormy, you could not measure the feed in tanks or any other way —at least, he could not—but if the weather was reasonably good, and if the feed tank were either coned or tapered up to the top, as it should be, there was really no difficulty in carrying out the measurement; by having tanks which were alternately filled and emptied, within a margin of error of considerably less than 1 per cent. He had had the tanks out and calibrated them after the trial, at the highest point to which he filled them and the lowest, so that he had been able to make certain what the probable error was.

Miscellaneous.

THE WINES OF LOS ANGELES.

The following is taken from a report by Major B. C. Truman, and published by the Los Angeles Board of Trade:—

"No one acquainted with the varied soil and diversified climate of California can doubt that it is to that State that the American people are to look for the wines which will in time take the place of the vintages of Bordeaux, Rheims, Epernay, Oporto, Madeira, and Tokay. We may not probably produce a Chateau Lafitte, a White Hermitage, or a Chablis for some time to come; we may never perhaps be able to produce similar wines, and even if we succeed to perfect processes of wine-making, and produce brands that are rich in bouquet and aroma, they may never, in the estimation of some, reach the perfection of those just named, and otherwise not be like them. No two wine-producing countries are precisely alike, although there may be similarity of climate, soil, cultivation, and manipulation. In California, grapes are grown in all kinds of soil, altitudes, and under very dissimilar atmospheric conditions, some of these conditions of climate, soil, and altitude resembling France and Italy, others Germany and Greece, others Spain and Portugal, whilst not a few of the Californian conditions are totally different from those of the European wine districts. Thus, to a great extent, the result will be the production of a new type, and our vintages with their pretty names may sound as sweetly in the ear of the connoisseur of the next generation as do Rousillion or Amontillado in our own.

"During the last thirty years improvements have been made, and are still being made, in the cultivation of the vine, and the processes of wine-making in California. Commissioners and experts have visited foreign countries, and skilled workmen from leading European vineyards and wine-houses have been brought over here at great cost. Cuttings from all the rare vines of Europe have been imported, and all possible information respecting the cultivation of the vine, and the processes of wine-making, have been collected from every available source. Some species do not take kindly to this new climate and soil, whilst others appear to have gained new virtues, and although we cannot always expect that the identical flavour of the wine from the imported vine will be repeated in their new home, still many show a decided improvement. There are Rieslings in the market now, and some rare old white wines without a name in many a cellar, which, had their bottles been decked with the picture of some ruined old castle, might pass for a real Teutonic article from the banks of the Rhine. Other wines, like the Cucamonga of San Bernardino and the Angelica of Los Angeles, are noted for their luscious sweetness. Other blendings, like Kohler's or Baldwin's Bonanzas, have a quaint and fascinating flavour, whilst there are ports enough like their namesakes to defy comparison, and some sherries and muscatels which at no distant date will substantially supplant that class of imported wines in the United States.

"As an illustration of the growing popularity of Californian wines at home (here in California), it is not too much to say that twenty years ago not ten gentlemen in the State ever placed either native wines or brandy on their table. Gradually, however, the white and red acid wines of Los Angeles and other counties improved, and were trusted, and now no Californian is ashamed of entertaining his guest with either the Sauterne, Hock, Muscatel, Zinfandel (claret), Riesling, or Burgundy of his native land. These wines are becoming favourites in the Eastern States, and even in England, and particularly among connoisseurs who know pure wines from adulterated ones. It also may not be generally known that certain French firms even export to their American customers red wines which were originally made in California and shipped to France for the purpose of adulteration, or, at least, deception. The port wine from Los Angeles county is undoubtedly the best, purest, and truest port used in the country. It is palatable, medicinal in its effects, and purer than any port that comes from foreign countries, or that is manufactured in the cellars of importing houses of New York and other eastern cities. The Californian sherry is also gaining in favour, and its sale is daily increasing in the East, and what has just been said of the Californian port and the foreign article holds good for the sherry of California and its rival from abroad.

The excellence of the Californian vintages lies in their absolute purity, but they lack age and that exquisite manipulation which imparts to imported concoctions a mellow taste and an acceptable aroma. There is a nutty flavour to the so-called cheap sherry from abroad that often pleases the senses more than

that of the unadulterated sherry from California, and whilst the former is actually guilty of deleterious effects, the latter is only deemed deficient in high-bred quality, which may be traced to its newness and nothing else. Angelica wine from Los Angeles county has always been a favourite in the East, and is the wine that attracted the admiration of the jurors at the Paris Exhibition in 1867.

There is no other vegetable growth in California which finds so generally a congenial place as the grape. It is a good bearer, and never fails if properly attended to. It never greatly suffers from cold or heat, or other elemental disturbance, and does not average one pound of decayed or indifferent berries in a thousand in the pickings. The vine suffers nothing from the elements as a general rule, although whole vineyards in the lowlands which have been primed too early have been injured by frost, and so rendered non-producing for one season. The phylloxera has as yet occasioned no alarm in Southern California, and has never been known to have injured what is called the natural Californica, Arizonica, or Missouri vine or stock. No fertiliser is used by the viticulturists, as the soil is too strong, if anything, to produce a grape which shall make a table wine with as little alcoholic per-centage as possible.

Los Angeles county, while it has achieved much success during the past 15 years in its production of hock, burgundy, and claret, excells more particularly in its port, sherry, madeira, angelica, and other sweet and heavy wines. The acreage of vineyards in Southern California is always increasing :—

	Acreage.	Number of Vines.
1856	1,800	1,500,000
1879	56,000	45,000,000
1880	68,000	55,000,000
1881	80,000	64,000,000
1888	150,000	120,000,000

The wine product of these vineyards for the past 11 years was as follows :—

	Gallons.
1877	4,000,000
1878	5,000,000
1879	7,000,000
1880	10,000,000
1881	8,000,000
1882	9,000,000
1883	8,500,000
1884	10,000,000
1885	11,000,000
1886	18,000,000
1887	15,000,000
1888 .. (estimated) ..	17,000,000

In addition to the large quantity of wine and brandy manufactured, 85,000 boxes of raisins were exported from Los Angeles county alone, whilst the entire raisin pack for Southern California amounted for the same period 1,250,000 boxes, as compared with only 11,000 boxes in 1875.

PRODUCTS OF THE PACIFIC COAST.

There are at least seven different products which are now almost exclusively confined to the Pacific States. Among these the canning of salmon occupies an important place. During last season not less than 1,000,000 cases of this fish were packed. This industry extends from the Sacramento river northward to the rivers and bays of Alaska. The development of this business in the future will be only limited by the demand at home and abroad for the product. It has already exceeded the home demand, and the export trade is now beginning to make a figure in the commerce of the Pacific coast.

There are no raisins produced in the United States outside of California, nor is it likely that much raisin country will ever be found outside of this State. The wine and raisin interest are almost exclusively confined to California. What wine is produced in Ohio and New York make no figure in the agricultural statistics of the country. As yet, there has not been any exact definition of the area of land in California adapted for the production of raisins, but it may be said safely, that not one-fifth of all the land suitable to that industry is to-day covered with vines. The 950,000 boxes of raisins and 20,000,000 gallons produced last season suggest the possibilities of the future.

The making of olive oil is also in its infancy, and is also almost exclusively confined to this State. There is little prospect that the area of olive orchards will be extended much beyond California, although the tree flourishes in some parts of Mexico. It is now about 100 years since the first olive trees were planted at the mission stations; but it is scarcely more than ten years since the manufacture of olive oil began to attract any attention here.

It is probable that the only State in the Union which will make any figure in the production of the dried figs of commerce will be California; and this will probably be true of apricots and prunes, although the exact limits, suitable to the production of these fruits, may be extended on the south beyond the boundaries of the State. Whilst oranges and lemons will not be confined to California, there is a good prospect that ten years hence these fruits will exceed in bulk and volume those produced in any other State in the Union.

AUSTRIAN SILK INDUSTRY.

The *Journal de la Chambre de Commerce de Constantinople* says that, strengthened by the protective duties imposed in 1878 and 1882, the silk industry in Austria has succeeded not only in checking French, Swiss, and Italian importations but in obtaining many important outlets abroad. The chief centres of the production are in the vicinity of Vienna, at St. Polten, Bruun, and Reichenberg. The material

principally employed is organzine. These silks are dyed in Vienna, with the exception of those requiring to be dyed black, which are sent for the purpose to Lyons or Crefeld. Besides organzine, raw silks and *schappe* are used. The productions consist of velvets pure, and of mixed silk, plain and figured satins, stuffs for umbrellas and linings, foulards, ribbons and gauzes, as well as various descriptions of stuffs of pure and mixed silk, plain and figured. The export articles are velvets, satins and ribbons, as well as stuffs for umbrellas and linings, while the foulards and gauzes are retained for home consumption. It is the stuffs of pure silk, plain and figured, and the velvets of pure silk which are exported in large quantities to England, to North America, and to some extent to Germany, Italy, and France. Stuffs of half silk in the piece, and velvets of half silk, find a market in the Danubian countries, in Turkey and in Germany—and the same with satins. Ribbons are exported to all countries of the world. The total value of the exports of silk tissues of all kinds from Austria amounted in 1886 to 6,163,300 florins, while the value of the imports amounted to 11,930,650 florins.

EDUCATION IN INDIA.

According to a Parliamentary paper entitled "Statement Exhibiting the Moral and Material Progress and Condition of India," progress in education continues in India. The number of schools and colleges rose in 1887 to 127,381, as compared with 122,643 in the year 1886, and the total number of scholars to 3,358,042, as compared with 3,339,061. Of this total only about 150,000 were girls, but the increase in the number of girl scholars has, during the last three years, been in a much larger ratio than the increase among boy scholars. A new university was opened at Allahabad in 1887, and India now possesses five universities, all of which hold examinations and grant degrees. The number of candidates for admission to the universities rose from 13,254 in 1886, to 14,732 in 1887, and the number of admissions from 4,231 to 6,224. The number of students who gained university degrees in 1887 were 826 in art and science, 80 in medicine, 37 in engineering, and 193 in law. A large number of medical students obtained diplomas as "hospital assistants in 1887, besides those who graduated in medicine. Of the Calcutta graduates in arts during 1887, two were women. The number of secondary, or higher schools for boys, has risen during the last five years from 3,932 with 215,731 pupils to 4,160 with 404,189 pupils; during the same period the secondary schools for girls have risen from 190 with 6,366 pupils to 357 with 24,904 pupils. The most important technical schools are the workshops at the great railways, at which some hundreds of apprentices, many of them holding scholarships or stipends from Government or from local bodies are learning mechanical engineering, smithy work, and carpentry. The number of pupils at engineering colleges and at art schools is very small, but the teaching of drawing and of surgery is being extended in most provinces. Now that primary and secondary schools are mostly under the control of municipal and local bodies, it is expected that technical teaching in the special handicraft or manufacture of each locality will be gradually increased.

Correspondence.

INDIAN AGRICULTURE.

After the close of the discussion which followed his paper on Indian agriculture, on the 8th inst., Professor Wallace put forward a statement which requires notice. In deprecating attempts to improve upon the native plough, he said that, as a matter of fact, "There was not an agricultural department which had not an English plough lying about somewhere because it had not succeeded," and that he "Saw ploughs of various description in Madras that, with one or two exceptions, had proved a complete failure." Mr. Wallace may not have visited any part of the Madras Presidency in which light iron and other improved ploughs are in use. But, as I stated, during the discussion, that the Swedish ploughs, which I caused to be sent out to Madras after the Vienna Exhibition, are appreciated and extensively used, I should like to quote authority for my statement.

I happen to have by me a copy of Madras Government Proceedings of 16th June, 1883, No. 748 (Revenue), in which the agricultural reporter to Government mentions that one firm, Messrs. Sahapathy Moodelliar, had introduced 334 Swedish, and 67 improved wood and iron ploughs into the Bellary district alone. The Director of Revenue Settlement and Agriculture endorsed thereon, "The demand for improved ploughs in Bellary steadily increases;" and the Government Order observes that "the difficulty and cost of effecting repairs appears to be the chief obstacle to the more extended use of European ploughs." It is also stated that similar ploughs were sent to the Kurnool and Dharwar districts, and to Hyderabad and Mysore. I know that they are in use in several other districts.

Two Madras firms (Messrs. Oakes and Co., and Messrs. Massey and Co.) are doing a good trade in making light iron ploughs, after the Swedish pattern, somewhat modified, as well as improved native ploughs. Such a manufacture and trade could not have sprung up without demand and appreciation.

A Madras newspaper, received to-day, dated 27th February, 1889, gives a report of an Agricultural Exhibition held in the Salem district, last month, in

which it is said that "Messrs. Massey and Co.'s ploughs presented an interesting exhibit, and it is to be hoped that the display of prize certificates hung in front of them will be an earnest of their success in providing the ryot with a better implement than he now possesses for tilling the land."

J. MICHAEL, Major-General.

Ascot, 17th March, 1889.

General Notes.

LIEGE COMMERCIAL MUSEUM. — The Liege Chamber of Commerce has recently set an example, says the *Journal de la Chambre de Commerce de Constantinople*, which might well be followed by other industrial centres. It has established a commercial museum on an entirely new system. This museum is divided into two sections. The first comprises the articles that Belgium is obliged to purchase from other countries, while the second contains samples of all the articles which are manufactured in Belgium. A library and an information bureau are attached to this museum.

EDUCATION IN PERU.—A report was recently made public by the municipality of Lima, with regard to the public schools in that city which are free, open to both sexes, and under good management. One hundred and forty of these schools are established and attended by 9,850 scholars, which, estimating the population of the capital at 120,000, would give about 8¼ per cent. on that number. The girls outnumber the boys by one-fifth. The studies pursued are elementary, and the superior schools and University of Lima afford further facilities needed. On the celebration of the National Independence anniversary, the municipality gives money premiums to the parents who are most diligent and constant in sending their children to the schools, as well as conferring substantial rewards on the deserving scholars.

"GRAPHIC" EXHIBITION AT STUTTGART.—Information has been received from the Foreign-office through the Science and Art Department, that a "Graphic" Exhibition is to be held at Stuttgart next June, in celebration of the King's Jubilee. This Exhibition is limited to firms or institutions of Wurttemberg. It will comprise the following sections:—1. All branches of the publishing business, such as books, musical works, and periodicals, as well as other auxiliary arts and processes, viz., engraving, lithography, chromolithography, xylography, zincography, photography, &c. 2. Collections of kindred articles belonging to, or represented by, subjects of Wurttemberg. 3. Bookbinders' work, book tools and stamps. 4. Paper, and wares manufactured from the same. 5. Mechanical processes in operation, especially in the form of type-founding and accelerated printing presses. 6. An historical display of ancient specimens of the graphic arts, as also of ancient Wurttemberg, artistic journals, illustrations, bindings, caligraphy, &c. The Royal Library, at Stuttgart, which possesses one of the richest collections of Bibles, will alone provide a choice display of manuscript and printed books.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings at Eight o'clock:—

APRIL 3.—"Fruit Growing for Profit in the Open-air in England." By W. PAUL, F.L.S.

APRIL 10.—"The Sanitary Functions of County Councils." By SIR DOUGLAS GALTON, K.C.B.

Papers for which no dates have as yet been fixed:—

"Secondary Batteries." By W. H. PREECE, F.R.S.

"The Use of Spirit as an Agent in Prime Movers." By A. F. YARROW.

"Origin and Manufacture of Playing Cards." By GEORGE CLULOW.

"Automatic Selling Machines." By J. G. LORRAIN.

APPLIED ART SECTION.

Tuesday evenings, at Eight o'clock:—

APRIL 9.—"Architecture in Relation to Landscape." By H. H. STATHAM. E. C. ROBINS, F.S.A., will preside.

MAY 14.—"Venetian Glass." By DR. SALVIATI.

FOREIGN AND COLONIAL SECTION.

Tuesday evenings, at Eight o'clock:—

APRIL 2.—"The Argentine Republic." By F. K. SMYTHIES. HYDE CLARKE will preside.

APRIL 30.—"A New Ocean Route to Siberia." By CAPTAIN WIGGINS, F.R.G.S.

INDIAN SECTION.

Friday evenings, at Eight o'clock:—

MARCH 29.—"The Progress of the Railways and Trade of India." By SIR JULAND DANVERS, K.C.S.I. SIR GEORGE BRUCE, P.Inst.C.E., will preside.

MAY 3.—"The Karun as a Trade Route." By MAJOR-GENERAL SIR R. MURDOCH SMITH, K.C.M.G. SIR LEPEL GRIFFIN, K.C.S.I., wil preside.

MAY 24.—"Indian Wheats." By JOHN McDOUGALL. J. M. MACLEAN, M.P., will preside.

Cantor Lectures.

Courses of Cantor Lectures will be delivered on Monday evenings at Eight o'clock:—

C. V. Boys, F.R.S., "Instruments for the Measurement of Radiant Heat." Four Lectures.

Lecture II.—April 1.—All instruments of an electrical character require a thread suspension—Properties of wire, spider, glass, and quartz threads—Silk and quartz compared—Details of the manufacture of quartz thread, and instructions for preserving and mounting them.

Lecture III. — April 8. — Thermo-piles and thermo-elements — Lord Rosse's arrangement—Hutchin's instrument—Professor Forbes' instrument—The advantage of reducing the size of the bars—Details of manipulation in the case of very small bars—The construction of galvanometers to be used with thermo-piles and for some other purposes.

Lecture IV.—April 15.—D'Arsonval's thermo-galvanometer—Boys' radio-micrometer—Application of the theory of the instrument to find the best proportions—Modification for showing vertical tremors—Spinning thermo-piles—Instruments depending on change of resistance—Langley's *bolometer*—Advantages and disadvantages of different instruments compared.

H. Graham Harris, M.Inst.C.E., "Heat Engines other than Steam." Four Lectures. May 6, 13, 20, 27.

MEETINGS FOR THE ENSUING WEEK.

Monday, April 1 ... SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. C. V. Boys, "Instruments for the Measurement of Radiant Heat." (Lecture II.)

Royal Institution, Albemarle-street, W., 5 p.m. General Monthly Meeting.

Engineers, Westminster Town Hall, S.W., 7½ p.m. Mr. G. M. Lawford, "Fire-proof Floors."

Chemical Industry (London Section), Burlington-house, W., 8 p.m. 1. Dr. P. F. Frankland, "The Action of Water on Lead." 2. Messrs. Cross and Bevan, "Economy of Pure Caustic Soda."

Medical, 11, Chandos-street, W., 8½ p.m.

Victoria Institute, 7, Adelphi-terrace, W.C., 8 p.m.

Tuesday, April 2...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Foreign and Colonial Section.) Mr. F. K. Smythies, "The Argentine Republic."

Royal Institution, Albemarle-street, W., 3 p.m. Dr. G. J. Romanes, "Before and After Darwin." II. "Evolution." (Lecture XI.)

Civil Engineers, 25, Great George-street, S.W., 8 p.m. 1. Adjourned discussion on Dr. Charles E. Emery's paper, "The District Distribution of Steam in the United States." 2. Sir Nathaniel Barnaby, "Armour for Ships."

Pathological, 53, Berners-street, Oxford-street, W., 8½ p.m.

Sanitary Institute, Parkes Museum, 74A, Margaret-street, W., 3 p.m. Dr. A. Wynter Blyth, "The Chemistry of Dairy Produce." (Lecture II.) 8 p.m. Dr. T. F. Murphy, "Infectious Diseases and Methods of Disinfection."

Biblical Archæology, 9, Conduit-street, W., 8 p.m.

Zoological, 11, Hanover-square, W., 8½ p.m. 1. Mr. W. K. Parker, "*Steatornis caripensis.*" 2. Mr. Oldfield Thomas, "Preliminary Notes on the Characters and Synonymy of the different species of Otter." 3. Mr. E. T. Newton, "A Contribution to the History of Eocene Siluroid Fishes." 4. Mr. A. Smith-Woodward, "Note on *Bucklandium diluvii*, Konig, a Siluroid Fish from the London Clay of Sheppey."

Wednesday, April 3...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. W. Paul, "Fruit Growing for Profit in the Open-air in England."

Geological, Burlington-house, W., 8 p.m. 1. Mr. R. N. Worth, "The Elvans and Volcanic Rocks of Dartmoor." 2. Mr. E. A. Walford, "Some Polyzoa from the Inferior Oolite of Shipton Gorge, Dorset." 3. Mr. F. A. Bather, "The Basals of Eugeniacrinidæ."

Cymmrodorion, 27, Chancery-lane, W.C., 8 p.m. Mr. R. A. Roberts, "The Public Records relating to Wales."

Entomological, 11, Chandos-street, W., 7 p.m.

Archæological Association, 32, Sackville-street, W., 8 p.m.

Obstetrical, 53, Berners-street, W., 8 p.m.

Civil and Mechanical Engineers, Westminster-palace Hotel, S.W., 7 p.m. Mr. James Bateman, "The Roadstones of Somerset and Wilts."

Thursday, April 4...Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

Linnean, Burlington-house, W., 8 p.m. 1. Mr. A. Lister, "Myscomycetes," 2. Mr. R. J. Harvey Gibson, "Helcion pellucidum." 3. Mr. W. E. Hoyle, "The Deep-water Fauna of Firth of Clyde."

Chemical, Burlington-house, W., 8 p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Professor J. H. Middleton, "Houses and their Decoration, from the Classical to the Mediæval Period." (Lecture III.)

Archæological Institution, 16, Burlington-street, W. 4 p.m.

Friday, April 5...United Service Inst., Whitehall-yard, 3 p.m. Mr. W. H. Deering, "The latest Improvements in Gunpowder and other Explosives."

Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting, 9 p.m. Rev. Canon Ainger, "True and False Humour in Literature."

Civil Engineers, 25, Great George-street, S.W., 7½ p.m. (Students' Meeting.) Mr. J. R. Durley, "Moulding and Casting Cylinders for Marine-Engines."

Geologists' Association, University College, W.C., 8 p.m. Prof. J. F. Blake, "A Visit to the Volcanoes of Italy."

Philological, University College, W.C., 8 p.m. Mr. W. R. Morfill, "An attempt to explain some Peculiarities of Modern Russian by Comparison with its Earlier Forms and with other Sclavonic Languages."

Sanitary Institute, Parkes Museum, 74A, Margaret-street, W., 8 p.m. Mr. J. F. J. Sykes, "General Power and Duties of Inspectors of Nuisances—Method of Inspection.

Saturday, April 6...Royal Institution, Albemarle-street, W., 3 p.m. Lord Rayleigh, "Experimental Optics." (Lecture VII.)

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FRIDAY, APRIL 5, 1889.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CANTOR LECTURES.

The second lecture of the course on "Instruments for the Measurement of Radiant Heat," was delivered by Mr. C. V. Boys, F.R.S., on Monday evening, April 1.

The lectures will be printed in the *Journal* during the summer recess.

Proceedings of the Society.

INDIAN SECTION.

Friday, March 29, 1889; Sir George Bruce, P.Inst.C.E., in the chair.

The paper read was—

THE PROGRESS OF RAILWAYS AND TRADE IN INDIA.

By Sir Juland Danvers, K.C.S.I.

It is always pleasant to be able to say something about progress, when it is in the right direction. I therefore willingly accepted the invitation of the Indian Section of the Society to report what has been going on in respect to railways and trade in India since I last had the honour of reading a paper to this Society on the subject. I expect, however, that much of that which I have to relate is known to many of my hearers. There is no lack of administration reports, trade returns, and statistical statements relating to India. It has been said that the Executive is overburdened with them. Be this as it may, information is open to all, on almost every subject connected with the country. He who runs may read. But while blue and yellow books contain very interesting matter, they are, I apprehend, "caviare to the general." It may sometimes be useful, therefore, to condense their contents, and to put them forward in a different shape.

The last account of railways in India which I gave to this Society was in February, 1877—just twelve years ago. Many changes have been going on since then in that country. A large province has been annexed. Important questions, affecting the social and political condition of the people, have been discussed. Trade has advanced with rapid strides, and new industries have sprung up. Imposts on internal and external trade have been abolished, and other fiscal reforms introduced. Distances have been abridged by steam and the Suez Canal, and improvements in marine machinery have brought India closer to England. The West is spoken of as being far from the East, but when a message can be received in this country hours before the time it is dispatched from Calcutta or Bombay, and when in the course of sixty days travellers from London can go to Bombay, cross the country to Calcutta, visit Darjeeling, and stand at the foot of the grand Himalayan range, to gaze on the magnificent snow mountains, from 20,000 to 25,000 feet in height—return by Benares, Agra, and Delhi, spending two or three days at each, and say, on reaching London, they have had a delightful, exhilarating trip—one feels the practical effect of modern facilities for locomotion. When Clive first went out to India, he was more than a year reaching Madras from England.

My purpose this evening is to describe the progress which has been made with the internal communications of India by means of railways, and then to examine the effects which they have had upon the trade and material improvements of the country. Before going into details, I would remind you that all the capital which has been expended on Indian railways has been provided from this country. They have been made with English gold, and the interest has been paid with Indian rupees, either from the profits of the lines or the taxes of the people. The particulars shall be given hereafter; I mention it now that I may call your recollection to a part of the speech touching upon this point which was delivered by

the late Viceroy, the Marquis of Dufferin, when on the eve of leaving India. After alluding to the responsibility of the governing power in India, in regard to the peace, the security, and the well-being of the country, he says, "To those obligations must be added the duty of watching over the enormous commercial interests of the Mother Country, represented by a guaranteed capital of £320,000,000, which, to the great benefit of India, has been either lent to the State or sunk in Indian railways and similar enterprises. It would be criminal to ignore the responsibility of the Government towards those who had sunk large sums in the development of Indian resources on the faith of official guarantees, or who have invested capital in the Indian funds at the invitation of the Imperial and Indian authorities. The same considerations apply with almost equal force to the further vast amount of capital employed by private British enterprise in manufactures, tea planting, indigo, jute, and similar industries, and on the assumption that English rule and English justice would remain dominant in India."

These are statesmanlike and practical remarks, and bring home to us the relations which exist between India and this country. Not only have the wisdom and power of England been applied to the consolidation of the Empire and to the government of the country, for the benefit of its various races and inhabitants, but the millions of capital of which Lord Dufferin speaks have gone to establish peace and security, to construct railways, telegraphs, and other works of public utility for its material improvement, and these vast sums have been advanced on terms which British administration alone could procure. Some may be inclined to say that India is not so valuable to us as we are to India. But the fact is the interests of the two countries are united, and, while opinions may differ as to the means by which the great Indian problem should be solved, all true Englishmen agree that our rule should be guided by justice, charity, and liberality, and with a desire to promote the interests of all classes of her Majesty's subjects there, whether native or European.

The progress which has been made with railways during twelve years is soon told. On the 1st January, 1877, 6,948 miles were open. In January, 1888, this was increased by 7,120 miles. There are now 14,890 miles open, and upwards of 2,400 are in course of construction. The 6,948 miles took 27 years to construct, and cost £109,364,800, or an average of £15,740 per mile. The additional length of 7,120 miles was made in eleven years, and has cost £73,514,400, or £10,320 per mile. The estimated amount expended on open lines to the end of 1888 is £187,226,000, making the average cost per mile of the whole system, broad and narrow, about £12,000. These figures show how much more rapidly and cheaply railways are now made than in the early days of construction. The reason is plain. We were buying experience during the operations of the first twenty years, and for a long time the expense and difficulty of moving materials to their destination was enormous. The Mutiny also intervened, and caused delay and destruction. The greater portion of the above-mentioned addition was also metre-gauge lines, which have no doubt cost much less to construct. Materials likewise sent out from England were very much dearer than they have been recently, and the cost of freight was higher. The substitution of steel for iron has in many ways aided economy. Steel rails are now supplied under £4 per ton, while as much as £13 7s. has been paid for iron rails, and £8 to £9 was a common price. A steel sleeper is also used and found very serviceable. Locomotive engines also are now obtainable at a lower price than was formerly given for an engine of much less size and power. Science and skill, as well as experience, have also introduced economies. This is exemplified in bridge-making. There was originally much trouble and expense with some of the river crossings. When railways were started in India, many difficulties were raised which disappeared on approaching them. But the danger which was hidden in the beds of rivers had not been appreciated, and was not always overcome when bridge construction commenced. In some parts of the country the soil is of a soft and shifting nature, and the stream is apt to change its course, leaving a bridge high and dry instead of crossing the water. The engineers had not been able to ascertain that the foundations of piers laid in such soil were subject to a scour of sixty and seventy feet, nor were there data to give trustworthy information as to the maximum volume of water that passed through a channel in the height of the floods. Some bridges, especially in the upper provinces, accordingly proved to be of insufficient stability, and were damaged and swept away by the force of the torrents. As in other matters, experience has been gained, and, in future, mistakes of a similar kind will not be made. Some noble structures

have been erected since 1876. Time would not admit of a description of each. A table is accordingly given (p. 454) with a summary of the main features.

One result of this increased knowledge and experience is that time and money have been saved in executing recent lines. The three railways which were first undertaken have cost upwards of £20,000 per mile, but it should be borne in mind that they are on the 5 ft. 6 in. gauge, and that a considerable portion is laid with a double line of rails. I allude to the East Indian, which cost Rs. 231,719 per mile; to the Great Indian Peninsula, which has cost Rs. 2,04,493; and to the Bombay and Baroda, which has cost Rs. 2,06,668; or the Oudh and Rohilcund, another broad-gauge line, which was commenced some time after these, and was only finished last year, cost only Rs. 128,595, although it includes in its system several large bridges, among them the "Dufferin" bridge at Benares. The Midland and the Bengal-Nagpur Railways, also of the 5 ft. 6 in. gauge, now in course of construction, are expected to cost about Rs.1,20,000 per mile, or under £12,000 per mile. The first metre-gauge line, completed in 1877, was the Rajpootana Malwa, and that has has cost Rs.69,066 per mile. The South Indian came to Rs. 74,304; the South Mahratta to Rs.80,125; the Burmah to Rs.84,295; the Tirhoot to Rs.70,333. The Bengal and North-West has been constructed at the rate of Rs. 60,235 per mile, while some provincial lines, also on the metre-gauge, in Oude and Rohilkund, have been made for Rs. 41,964 and Rs. 33,207, and in the Guicowar's territory they have cost Rs. 22,823 and Rs. 28,415 respectively, without rolling stock. Under very favourable circumstances the cost has, in some districts, been reduced to Rs. 18,436 and Rs. 16,272. Instances of these occur in the Native States of Jodhpore and Morvi, in the latter of which, however, the gauge is 2 ft. 6 in.

As an example of the saving of time, we may compare the first section of the East Indian Railway, from Howrah to Raneegunge, a length of 121 miles. This took four years to complete, being at the rate of about 12 days per mile; while the Bengal-Nagpur, from Naudgaon to Bilaspur—a distance of 109 miles, was made in 18 months, or at the rate of five days per mile. Again, compare the Madras broad gauge with the Midland broad gauge. The construction of 402 miles of the former occupied seven years and nine months, or seven days per mile, while 333 miles of the latter were completed within three years, at the rate of about three days per mile. The South Indian, a metre gauge line of 412 miles, was seven years and four months in course of construction—between 1872 and 1879—being at the rate of 6½ days per mile; while the Tounghoo-Mandalay Railway, 223 miles, just completed, was made at the rate of 3½ days per mile, and the Bengal North-West, of 376 miles, was finished within four years — at 3¾ days per mile. Greater rapidity than this has, on an emergency, been attained. In 1874, when it was of great importance to provide the means of conveying food-grains into certain famine-stricken districts, a section of the Tirhoot Railway, 48 miles in length, was constructed in as many days. It was, of course, done roughly, but it included the crossing of three rivers, and was made capable of sustaining a traffic with heavily-laden trains.

The following railways have been undertaken during the last twelve years, some by the State and some by companies under contract with the Government. Their direction and objects will be seen by a glance at the map. The rulers of native States have also been coming forward to construct railways in their several territories, by which they not only benefit themselves but assist towards the completion of a general system of inter-communication for the whole country.

A list of the railways which have been made under these different auspices is given in pp. 455 and 456.

It will be seen that our foreign neighbours have also supplied railways in their limited territories. The French, at Pondicherry, have constructed a line 7¾ miles in length, which joins the South Indian Railway, and is worked by that company. The Portuguese Government have also established railway communication from their seaport, Marmagao, where they are forming a commodious harbour, to their frontier on the hills, about 51 miles from the coast. Here it joins the South Mahratta Railway, and a valuable outlet for the trade of this part of India is thus provided.

Progress in all directions has then been considerable; but there is no cause for boasting. More railways are required, and it is hoped that private enterprise will step in and provide what is wanted. Government has done much, but the taxes of the country cannot stand a larger demand upon them than they at present bear; and, except for purposes of defence and protection against famine, the Imperial Government will probably, for the

RAILWAY BRIDGES IN INDIA.

Railway.	Name of Bridge.	No. of spans.	Span in clear feet.	Length of Bridge.	Depth of foundation below low water.	Height from low water level to underside of girders.	Total weight of girders.	Cost of work to girder level.	Total cost of girders.	Cost of protective works.	Total cost including cost of protective works.	Cost per lineal ft. excluding protective works where separately stated.	Cost of erection of girders, per ton.	
			feet.	feet.	feet.	feet.	tons.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	
East Indian...	*Jubilee* .... (over the Hooghly, between Hooghly Station on the E. I. R., and Naihâti on the E. B. R.)	3	1 of 532·92 1 of 106·50 1 of 523·67	1,213·25	98·50	55·00	3,460·15	29,26,768	21,78,852	...	51,05,620	4,208	...	Opened by Viceroy on 21st February, 1887. According to the original design, this bridge consists of a central double cantilever girder, 320 ft. long, resting on two piers placed 120 ft. apart, centre to centre, in the middle of the channel; of two main girders, each 440 ft. in length, one on each side of the central cantilever girder, one end resting upon the latter, and the other end upon the shore abutment; and of two masonry viaducts, each 450 ft. in length, extending inland from each shore abutment.
Oudh and Rohilkund.	*Dufferin* .... (over the Ganges at Benares.)	16	7 of 331 9 of 104	3,518	25 to 141	75·32	6,780	18,36,032	41,80,170	1,15,356	61,31,558	1,710	47	Opened by Viceroy on 16th December, 1887. The bridge consists of 7 spans of 331 ft., with an extension on south bank of 9 spans of 104 ft. The girders are of steel. The flooring of the bridge at rail level is adapted to ordinary wheel traffic, and is carried on the lower booms of the large and the upper booms of the small spans. A clear headway of 25 ft. is given above the estimated highest flood level.
Indian Midland.	*Jumna* .... (Kalpi.)	10	250	2,640	90	76·63	3,200	12,74,710	10,49,049	1,12,500	24,36,259	879	107	Bridge finished in November, 1887; line opened on 1st February, 1888. Abutments and piers built for double line, but girders for one line only erected.
North-western	*Alexandra* .... (over the Chenab between Wazirabad and Kathâla.)	64	133·50	9,088	75	20	5,248	24,03,756	19,94,271	9,40,336	53,38,363	484	121	Opened by Prince of Wales in January, 1876.
Do.	*Attock*	5	2 of 308·40 3 of 257	1,655	*	111	2,202	14,77,580	15,96,980	1,45,956	32,20,516	1,857	437 252	This bridge has the rails above and a military road below. Opened on 24th May, 1883. Main girders are of Siemens steel of triangulated description. Each pier consists of a cluster of 8 wrought-iron box pillars, secured by horizontal and diagonal bracing.
Do.	*Chenab* .... (at Ramuwalla.)	27	150	4,050	70	...	...	...	...	8,83,680	46,24,096	...	...	The piers are single wells, 25 ft. in diameter, of brickwork, headed with concrete. It was commenced in November, 1887, and is expected to be completed this year.
Do.	*Kaisir-i-Hind* ... (at Ferozepore.)	27	144·50	4,293	78	26	6,000	14,89,552	15,43,730	10,21,020	40,54,302	706	50	Opened 8th May, 1887. Rails below and roadway above. Steel girders on brick piers 26½ ft. by 14½ ft., with rounded cutwaters. Piers are built on wells 23 ft. in diameter, headed with Portland cement concrete.
Do.	*Victoria* .... (over the Jhelum at Chucknizam.)	17	150	2,720	82	19	2,988	7,71,929	8,12,768	3,41,457	19,26,154	576†	66†	Opened 16th May, 1887. Combined road and railway on same level, with footway on each side, supported on wrought-iron brackets, and provided with handrail. Steel girders founded on single wells of 25 ft. external diameter.
Do.	*Sukkur* .... (over Indus.)	4	1 of 790 1 of 270 1 of 230 1 of 90	over Rohri channel (between centres of pillars). Cost of bridge Rs. 43,10,755. „ Sukkur channel.										Constructed like the Forth bridge on the cantilever principle; two cantilevers going out from the river bank; cantilevers project 295 ft., and a lattice girder of 200 ft. joins them. Single roadway 18 ft. wide in the clear, a single line of railway being laid in the centre; a path, 4 ft. 6 in. wide, for foot and pony traffic outside railway on each side of it.
Oudh and Rohilkund.	*Balawala*	11	248·17	2,904	100	39·94	3,944	10,17,294	10,86,000	5,04,169	26,07,463	724	337 ‡	Opened 9th May, 1887.

* Pier No. 1.—All standards and struts are founded at same level, viz., 343·68, or 21·68 feet above low-water level. Pier No. 2.—All standards and struts are founded at same level, viz., 319·12, or 2·88 feet below water level. Pier No. 3.—Up stream strut on east side of pier was founded at 311·88, or 10·12 feet below low-water level All other standards and struts founded at same level, viz., 313·30, or 8·70 feet below low-water level. Pier No. 4.—Two main standards and one down-stream strut, all on west side of pier, were founded at 337·29, or 18·29 feet above low-water level, All other standards and struts founded at same level 343·29 or 20·29 feet above low-water level.

‡ Including cost of girders. † Includes Rs.18,000 cost of staging.

present, hold its hand, and limit its encouragement to the grant of every possible facility, short of pecuniary aid, to private enterprise.

A Bill has been introduced into the Legislative Council for the purpose of consolidating and amending the law relating to railways in India, and for adding provisions which the extended system of lines and the multiplication of administrations has made advisable. One important object is to afford facilities for through traffic arrangements, both in the country itself and with countries beyond sea, and to define the responsibilities of the various parties engaged in such traffic. A satisfactory settlement of such questions, and a right understanding of the relations between railway companies, the public, and the State, will, it is hoped, tend to encourage private enterprise.

The question of railway extension in India

LINES UNDERTAKEN SINCE 1877.

BY COMPANIES.

Name.	Guage.	Length.	Direction.
		Miles.	
Oudh and Rohilkund	5 ft. 6 in.	$175\frac{1}{4}$	Moradabad to Saharanpur, &c.
Southern Mahratta	Metre.	$173\frac{1}{2}$	East Deccan, Hotgi-Gadag.
		$234\frac{1}{4}$	South ,, Guntakal to Portuguese frontier.
		$277\frac{1}{2}$	West ,, Poona-Londa.
		81	Southern Extension, Hubli-Harikar.
		$766\frac{1}{4}$	
Bengal and North-Western	Metre.	$376\frac{1}{4}$	
Bengal Central	5 ft. 6 in.	$125\frac{1}{4}$	
Indian Midland	5 ft. 6 in.	$317\frac{1}{4}$	Main line, Cawnpore-Bhopal.
		$180\frac{3}{4}$	Ihausi Mankipur.
		60	,, Gwalior.
		$46\frac{1}{2}$	Itawa-Sangor.
		$604\frac{1}{2}$	
Bengal Nagpur	5 ft. 6 in.	481	Asansol-Nandgaon.
		7	$10\frac{3}{4}$ miles from Asansol to Equ'table Coal Company.
		197	Bilaspur-Katni.
		685	
	Converted from 3 ft. 3 in. to 5 ft. 6 in.	146	Raj. Nandgaon-Nagpur.
		3	Dowhali Junction-Tumsar.
		797	
Rohilkund-Kumaon	Metre.	$54\frac{1}{2}$	Bhojeepura-Kathgodam.
Tarakeshwar	5 ft. 6 in.	$22\frac{1}{4}$	Seoraphuli-Tarakeshwar.
Bareilly Philibhit	Metre.	36	Bareilly-Pilibhit.
Lucknow-Sitapur-Sihramau	Metre.	124	Lucknow-Sihramau.
Delhi Kalka	5 ft. 6 in.	$157\frac{1}{2}$	Delhi-Umballa-Kalka.
East Indian	5 ft. 6 in.	$15\frac{1}{4}$	Branches.
North-Western	5 ft. 6 in.	$32\frac{1}{2}$	Ferozepore branch.
Madras	5 ft. 6 in.	14	Branches.
South Indian	Metre.	39	Chingleput-Conjeeveram.
Darjeeling Himalaya	2 ft.	51	Siliguri-Darjeeling.
Deoghur	Metre.	$4\frac{3}{4}$	Baidyanath-Deoghur.
Thaton Duyinzaik	2 ft.	8	Thaton-Duyinzaik.
Dibru Sadiya	Metre.	$77\frac{1}{2}$	Dibrugark to Jalap and branch.

BY STATE.

Name.	Guage.	Length.	Direction.
		Miles.	
Patna Geja	5 ft. 6 in.	57¼	Bankipore-Geja.
Dildarnagar Ghazipur	5 ft. 6 in.	12	Dildarnagar-Tari Ghat.
Bellary Kistna	Metre.	276½	Guntakal Junction-Kistna river.
Cuddapore Nellore	Metre.	82¾	Nellore-Tirupati Town.
Bezvada Extension	5 ft. 6 in.	21½	Hyderabad frontier-Bezvada.
North-Western	5 ft. 6 in.	104½	Lahore-Peshawur.
		96¼	Branches.
		62½	Sind Sagar, Eastern branch.
		295	,, Western ,,
		49¼	Branches.
		334	Sind Pishni main line.
		66	Quetta loop.
		52½	Hirok-Bostau.
	Metre.	10	Hirok-Kotal.
Tounghoo Mandalay	Metre.	223½	
Eastern Bengal	5 ft. 6 in.	5¾	Bhairamara-Golabnuggur.
		23¼	Calcutta-Naihate.
		29¼	Diamond Harbour.
		2¼	Kidderpore Dock.
	Metre.	19¼	Dinagepore branch.
	2 ft. 6 in.	37	Kaunia-Dharlla.
	Metre.	86	Dacca section.
		155¼	Assam-Bellar branch.
Tirhoot	Metre.	22½	Semaria-Dalsinghsarai.
		66½	Eastern branch.
Amritsar Pathankot	5 ft. 6 in.	66¾	Amritsar-Pathankot.
Burmah	Metre.	172	Rangoon-Tounghoo.
Jorkat Assam	2 ft.	30¾	Gosáigáon-Titabar and branches.
Cherra Company Gunj	2 ft. 6 in.	15	Company Gunj-Thariaghat.

BY NATIVE STATES.

Nizams	5 ft. 6 in.	370½	Secunderabad-Chauda (frontier).
Gaekwar's Meksana	Metre.	27¾	Meksana-Kheratu.
Bhopal Itarsi	5 ft. 6 in.	57	Itarsi-Bhopal.
Bhavnagar Gondal	Metre.	328¾	Bhavnagar-Bandar-Dhoraji and branches.
Morvi	2 ft. 6 in.	68	Wadhwau-Morvi.
Jodhpore	Metre.	123¾	Marwar Junction-Jodhpore and branches.
Rajpura Patiala	5 ft. 6 in.	15	Rajpura-Patiala.
Kolhapur Miraj	Metre.	28¾	Kolhapur-Miraj.
Jammu Kashmir	5 ft. 6 in.	24½	Sialkot-Jammu.

BY FOREIGN STATES.

Pondicherry	Metre.	7¾	Gingee River to Pondicherry.
West of India Portuguese	Metre.	51	Mormugao to Portuguese frontier.

has more than once engaged the attention of Parliament within the last ten years. In 1884, a Special Committee was appointed to look into the matter, and after hearing evidence from almost every quarter in which opinions and experience were available, the Committee reported that they considered "The evidence in favour of a more rapid extension of railway communication to be conclusive." With regard to the means by which this extension should be carried out, they were of opinion that it was desirable to employ both the agency of the State and of companies, and they thought that "The time may come when new railways will be made in India by unassisted private enterprise."

It is scarcely necessary to explain that the refusal of Government to grant a guarantee arises from no indifference to railway extension. When, therefore, such assistance is denied to any particular scheme, it is not, as has been sometimes argued, because they are of opinion that it could not be remunerative, and is not worthy of support, but because they think the time has arrived when projects which are advocated by the mercantile community of this country and of India should be undertaken in a purely enterprising spirit; and because they consider that the taxpayer of India should not continue, in the present reduced value of silver compared with gold, to increase the loss which yearly occurs in paying guaranteed interest in this country. A wider interest in Indian railways has no doubt been awakened during the last five years, and symptoms of private enterprise, unsupported by Government crutches, may be observed.

Besides the 2,476 miles now in course of construction, there are several projects in contemplation, which, it is understood, may be taken up by such agency. A line has been proposed from Chittagong to Assam, and careful surveys have been made of it. Another line, along the west coast, from Bezwada to Cuttack, has also been surveyed, and one on the same coast, from Puri, New Cuttack, where the famous temple of Juggernaut attracts its millions of pilgrims, *viâ* Sambulpur, to a point on the new Bengal-Nagpur Railway, is spoken of. Various lines between Benares and Calcutta, some taking a direct and some a circuitous route, have also been under consideration. A mountain railway, from the plains, at a point on the present Madras line, to Conoor, on the Nilgherries, is also in contemplation.

A line has just been undertaken by a company between Delhi, Umballa, and Kalka, on the way to the summer residence of the Government at Simla, the capital for which has been subscribed, without any guarantee from Government, but on conditions which ensure its economical working, viz., at the rate of 50 per cent. of its gross receipts, through the East Indian Railway. Those who have taken it up are sanguine that, under this favourable arrangement, it will prove remunerative.

Among the railways of the future is an ambitious scheme, advocated by the intrepid and enterprising explorers, Mr. Colquhoun and Mr. Holt Hallett, for connecting Burmah with South-Western China by a line through Siam. This, or other lines proposed with the same object, would, no doubt, be valuable communications as trade routes, and would promote the interests of the countries concerned as well as of the manufacturing industries of the United Kingdom. There would be physical difficulties in the way, but nothing is impracticable with engineers. The first and great difficulty, as in most enterprises, is money.

Before leaving the subject of new lines which have been constructed, or are in course of construction, I ought to allude to the important system of frontier lines which were undertaken during Lord Dufferin's viceroyalty. There is scarcely a railway in India which would not, to some extent, contribute towards the security and defence of the country in the event of disturbance or war, but these lines were made specially for defensive purposes, and properly come under the designation of strategic. Starting from Gujrat, on the North-Western line between Lahore and Peshawur, a line proceeds *viâ* Shahpur to Mianwali, and then runs south, parallel to the Indus, to Moultan, where the original Indus Valley railway is joined. At Sukkur, some miles lower down, the river is crossed by the stately railway bridge, opened, it is believed, the day before yesterday, and another line here branches off in a north-westerly direction to Sibi, where it bifurcates, one taking the course of the Bolan Pass and Quetta, and the other the Pishin Valley, to Bostan, where they re-unite and make for the mountain chain through which a tunnel is now being cut to Chaman, on the British frontier. Chaman is about 100 miles from Kandahar. There are other branch lines connected with the system but I need not describe them particularly. The works have been formidable, and the operations, especially in Beloochistan, have been subject to many obstacles, which have

called forth the energy, courage, and skill of those who were engaged in them. Not only had they to contend against the physical difficulties of the country, but the pestilential nature of the climate. The whole length will be 870 miles, and the cost about £11,000,000.

This expenditure, while large, has been money well spent, and is justified for the same reasons as those which have recently convinced this country that the strength of our navy should be increased, and that our ports, harbours, and coaling stations should be defended. It is, in fact, an insurance fund. There is no disguise about the matter. It is intended that we should be ready for any contingency, and that our position should be impregnable. This is the best security against intrusion. But it may be said, in favour of these defensive works, that they will not only fulfil the primary object for which they were designed, but will bring with them all the civilising influences and material advantages which railways always confer on countries where they are introduced for the first time. We cannot all at once expect that the predatory and lawless tribes which inhabit these border lands will turn their spears into pruning hooks; but we may hope that the greater facilities given to the cultivation of the soil by means of irrigation works, now being provided, and to the exchange of commodities by the railways, will turn their attention to agriculture and trade, and, in time, substitute peaceful occupation for the wild and warlike pursuits to which they have been habituated for generations. Some pecuniary return for the outlay may also be expected from the traffic. Thus profit, in the double shape of security and interest, will be realised; and peace perhaps, in a double sense, may be secured.

It will not be inopportune here to give a practical example of the value of railways for moving troops. During the military operations in Afghanistan, in 1878-79-80 (which was the first time, except for a short period during the Mutiny, that railways in India had been called upon to afford any material assistance during war), a mixed force or 4,000 men were conveyed daily from Delhi and Lahore, a distance of about 350 miles, and of 3,000 men between Lahore and Mooltan, the lines being single. In this manner 336,000 troops, besides 80,702 horses and mules, 9,577 camels, 11,816 bullocks, 414 guns, and 2,749,605 maunds of stores, and 681,653 maunds of railway materials, were conveyed in the two campaigns.

Alluding to the same campaign, Colonel W. S. Trevor, R.E., V.C., then Secretary to the Government, said that, "The saving of human life and suffering effected by the railway in transporting the troops across the Kachi Desert can hardly be over-estimated." He doubted, in fact, whether the operations could otherwise have been accomplished, and showed that "one single railway train did, with comparative ease, in one day of 16 hours, what it would have taken 2,500 camels to do in a fortnight."

Railway Volunteer Corps have been formed all over the country. The total enrolled strength last March was 7,264, representing 75 per cent. of the European and East Indian *employés*. The larger corps were those of the East Indian Railway, which numbered 1,149; the Bombay and Baroda with the Rajputana-Malwa, 1,076; the Great Indian Peninsula, 1,058; the North-Western Railway, 977; and the Madras, 837. But whether large or small, they provide a very efficient body of men, who are well trained and of good physique.

Descriptions, which might interest some here, could be given of various features in the construction and working of Indian railways, such as the mode adopted of scaling the Bolan Pass and the Western Ghâts, the principles on which various bridges have been constructed, the tunnel through the Amram mountains, the steel permanent way adopted on many lines lately, but I am not competent to enter into technical subjects, and time would not admit of my doing so if I were. I will only mention, as a matter of fact, that 8,445 miles of 5 ft. 6 in. gauge lines are worked by 2,271 locomotives, and the 5,007 miles of metre gauge lines are worked by 1,093; that there are altogether 46,628 vehicles for passengers and goods for the former, and 23,416 for the latter. I may add that the first-class passenger engines on the 5 ft. 6 in. gauge are, in every respect, equal in weight, power, and speed, to those on English lines. I have travelled at the rate of from 50 to 60 miles an hour on the East Indian Railway, and at 40 miles an hour on the Rajputana narrow gauge line.

It is now time that I should give the financial results of the working of these 14,528 miles of railway, which have cost £186,000,000, and show what progress has been made in this respect. Table A (p. 459) gives the gross and net receipts in 1875, 1880, 1885, and 1887, and an approximate estimate for last year. Leaving the last on one side, as being still somewhat uncertain, it will be seen that

in 1875, on an expenditure of £105,790,929, 6,497 miles earned a net revenue of £3,647,868, and yielded a dividend of £3 8s. 9d. per cent. In 1885, a sum of £9,126,331 was earned by 12,280 miles, which had cost £161,917,840, giving a dividend of £5 12s. 10d. per cent. In 1887, 14,383 miles were open; the capital expenditure was £182,879,655, and the revenue realised £9,364,821, yielding a return at the rate of £5 2s. 5d. per cent. These results, it will be understood, were produced from lines many of which had been at work for only a few years; some had only just been opened, and a considerable proportion were made for strategic and famine purposes. A portion of the capital on which the average dividend is calculated, represents also unfinished and unopened lines, which necessarily are a deadweight on the whole. Some lines, of course, earned higher than the average rate. The East Indian, for example, yielded £8·75 per cent.; the Great Indian Peninsula, £8·06; the Bombay and Baroda, 7·80; and the Rajputana-Malwa, 6·56 per cent. Taking the whole system, and classifying it according to its earnings:—6,368 miles yielded £7,544,866, and earned more than 5 per cent.; 347 miles yielded £101,445, and earned more than 4 per cent.; 2,039 miles yielded £635,836, and earned more than 3 per cent.; 5,305 miles yielded £1,082,674, and earned under 3 per cent. Of the 14,889 miles completed, up to the present time, 3,936½ have been open 20 years; 3,385¾, 10 years; 2,823¼ 5 years; 4,743½, less than five years.

TABLE A.

Year.	Capital.	Gross Receipts.	Net Receipts.	Per-centage of Net Receipts to Capital expended.
	£	£	£	
1875...	105,790,929	7,412,079	3,647,868	3·44 = £3 8s. 9d.
1880...	129,098,964	12,099,593	5,907,422	4·57 = £4 11s. 5d.
1885...	161,917,840	17,989,625	9,126,331	5·64 = £4 12s. 10d.
1887...	182,879,655	18,468,129	9,364,821	5·12 = £5 2s. 5d.
1888*	196,200,000	19,620,400		

* Partly estimated.

Table B shows how the results above given were obtained. It will be seen that in 1875 the

TABLE B.

Year.	Goods. Live Stock. No. of Head.	Live Stock. Receipts.	Goods carried by Rail (including minerals). No. of Tons.	Goods carried by Rail. Gross receipts.	Steamboats. No. of Tons.	Steamboats. Gross Receipts.	Total No. of Tons.	Total Gross Receipts.
		£		£		£		£
1875..	*505,621	21,845	4,927,157	4,598,113	41,466	78,548	‡4,968,623	4,698,506
1880..	†713,639	68,416	9,319,421	7,593,832	19,749	9,461	‡9,339,170	7,671,709
1885..	Tons. 32,888	66,395	18,892,497	11,848,979	..	..	18,925,385	11,915,374
1887..	28,952	59,616	20,166,725	11,869,706	..	..	20,195,677	11,929,322

* Roughly, 10,728 tons. † Roughly, 37,045 tons. ‡ Does not include live stock.

Passengers. No. of Passengers carried by Rail (including season ticket holders).	Gross Receipts.	Steamboats. No. of Passengers.	Steamboats. Gross Receipts.	Miscellaneous Receipts.	Net Receipts from Goods, Passengers, and Miscellaneous.
	£		£	£	£
26,787,067	2,453,136	9,859	6,482	226,153	3,647,868
48,066,004	3,802,308	56	80	581,053	5,907,422
80,864,779	5,538,126	....	....	*536,123	9,126,331
95,411,779	6,031,067	....	....	*507,738	9,364,821

* Includes all steamboat receipts.

gross receipts from passenger and goods were £7,384,277, and the net receipts £3,647,868. In 1887 the gross receipts were £18,468,129, and the net receipts £9,364,821.

TABLE C.

	Tons carried on the railways in 1875.		1887.
Coal	526,900	....	1,684,313
Cotton	233,750	....	553,850
Grain	569,297	....	3,971,903
Jute	95,864	....	478,522
Oil	24,668	....	102,741
Piece goods ..	96,320	....	218,908
Rice	*210,066	....	—
Salt	370,346	....	1,090,943
Seeds........	†429,322	....	—
Tobacco	39,311	....	104,001

This Table gives the quantities of some of the principal articles conveyed in the two years. Coal has increased from 526,900 tons in 1875 to 1,684,313 in 1887; cotton from 233,750 to 553,850; grain and seeds from 1,208,685 to 3,971,903; jute from 95,864 to 478,522; piece goods from 96,320 to 218,908, and salt from 370,346 to 1,090,943.

The total quantity of goods carried has increased from 4,968,623 tons in 1875 to 20,195,677 in 1887. The number of passengers has progressed in almost a similar proportion. In 1875, the number carried was 26,787,067; in 1887, 95,411,779. The proportion of first, second, and third class passengers continues about the same. In 1875, the lowest class formed 96·92 per cent., and in 1887, 97·33; the second class 2·30 and 2·24, and the first ·78 and ·43 per cent. respectively.

The cost of working and maintenance varies considerably on different lines. The average is about 50 per cent. of the gross receipts. Several of the large and important lines work below the average. The East Indian, for instance, was worked at under 32 per cent., the Great Indian Peninsula at less than 47 per cent., the Bombay and Baroda at about 42 per cent., and a line constructed by the Maharajah of Jodhpore at about 40 per cent. in the year 1887.

I could say a great deal about working expenses, and load this paper with statistics on train miles, ton and passenger miles, and could make use of numerals up to billions, but I am bound to be merciful to my hearers, and must avoid going into too much detail. I will only say that, in my belief, no line in the world is worked more economically than the 1,518 miles of the East Indian Railway. It is, as I have already stated, worked at 32 per cent. of the gross receipts. The gross receipts per train mile are 5·31 rupees, and the working expenses 1·69. The average cost of hauling one passenger one mile was ·71 pies,* while the amount received was 2·70. The average cost of hauling one ton of goods was 1·90, and the average sum received 5·83 pie. Thus, while its charges to the public are exceptionally low, its receipts are exceptionally high. Cheap coal, favourable gradients, and a large traffic, no doubt, favour this line, and it is the cheapest worked as well as the most profitable, but others approach it, and an examination of the tables in the annual report will afford an hour's entertainment to those who like to study statistics on the subject.

With regard to the future working of the railways, one of the first things that strikes one as inevitable is that the competition already begun will increase. Nor is this altogether to be regretted, provided the competition is kept within due bounds. The competition will in some cases be between the same places by different routes, such as the lines from Cawnpore, and Agra to Bombay; but it will be no less keen between the different ports and a central zone, such as from Oude to Calcutta and Bombay, and from Central India to those places; also between certain parts of the Punjab and Bombay and Kurrachee. Excessive competition will be avoided by proper regulations against undue preference, and by establishing minimum rates below which companies and administrations will not be allowed to charge. A further security will be found in the fact that the Government who, from the necessities of the case, have either acquired, or have a proprietary right in all the railways, have also a deciding voice in the construction of new lines, and will protect its own interests and those of the country, by preventing the creation of competitive lines, which are not warranted by the requirements of the country. Competition then will be regulated by distance, by rates within a minimum, by economy of working, regularity and good management, and by the charges and dues at the different shipping ports. The *laissez faire* system will not be applied to India as in America, where railway companies, being very much left to take care of themselves, have in many instances failed to

* Some included under "Grain."

† Rice and seeds not given separately in 1887.

* A pie at the present rate of exchange would be about one-third of a farthing.

do so, and pursue a warlike policy, which must end either in the survival of the strongest, or in making peace on terms which probably involve a combination against the public interests.

It has become the habit of late years to hold periodical Conferences, at which representatives of the Government and of the various railway administrations attend. The object is to discuss matters affecting the regulation of traffic and rates, the interchange of rolling stock, the classification of goods, &c., and to come to an agreement in regard to arrangements which shall be for the general advantage of the railway system as a whole. The practical benefits to be derived from such meetings is too clear to need comment. One effect will probably be to mitigate competition, and to introduce a spirit of conciliation between different administrations.

There has been a general inclination to reduce rates and fares during the last twelve years, so as to meet the capacities of the people and the circumstances of the country. The passenger fares vary from 18 to 12 pies per mile for first-class; from 9 to 6 pies for second-class; and from 3 to 2 pies for third-class. Three pies are now equivalent to about a farthing. There are five classes of goods, but special rates are frequently made for long distances. These apply generally to food grains and coal, and are as low as 3·27 pies per ton per mile for the former, and 3·89 for the latter. The next lowest vary from 12·27 to 9·07 pies, and the highest from 48 to 27·22 pies per ton per mile.

The regulation of charges has been much assisted by the statistical returns, which show the ton mileage and the average cost on each railway, of conveying one ton of goods and one passenger one mile.

While the Government, on the one hand, are desirous of encouraging private enterprise, and of avoiding injury to the property of the State, they have, on the other hand, to guard against a policy which would deprive the country at large of the advantage of railway extension. By the arrangement with the East Indian Railway Company, when that line was purchased, and by the terms of the contract, made within the last few years, with the South Mahratta, the Indian Midland, and the Bengal-Nagpur Companies, the threefold object has been secured, of establishing more railways, of giving the State a due share in the benefits, and of preserving its proprietary rights.

With regard to the agency best applicable to the management of railways in India, a good deal may be said. Some are in favour of an exclusive State management, and some are in favour of employing companies only, and some, like the Committee of the House of Commons, would allow both to go on together. Lord Dalhousie inaugurated the system of guaranteed companies, but both have been introduced, and both may be said to have been successfully worked. Much depends upon the individuals employed, and there have been excellent managers under each plan. In these days, however, when we are doing our utmost to avoid unnecessary centralisation, and to ease the shoulder of the Imperial Government of the burden of managing what others can do as well as itself, the management of railways would appear to be one of the first administrative functions to which the principle should be applied. On the broad question of decentralisation, I should like to quote the remarks of Sir John Strachey, in his recent lectures on "India." He says, "In the earliest times, when there were no railways, no telegraphs, and hardly any roads, the duties of the Government were very different from what they are now. Kingdoms were annexed and conquered, and stirring events were constantly going on, but the ordinary business of the central Government was comparatively small. But in the years immediately preceding the Mutiny of 1857 rapid changes had begun in all branches of the administration, and when the great reign of Lord Dalhousie was over, he declared it to be morally and physically impossible that the Governor-General should efficiently discharge all the duties imposed upon him."

Rules under legislative sanction were accordingly made by which those duties were lightened, and subsequent measures have been adopted for separating the various branches of administration and for the devolution of much of the responsibility and administrative work of the country to local authorities. This prinple of decentralisation has received considerable aid from railways, which should be the foremost to enjoy its advantages.

If a State guarantee is given, a control by the Government is, of course, necessary, but an agency may then be so constituted that, while State interests are protected, actual management may be conducted separately. As I have said, both systems are now at work in India, and I do not deny that there are advantages in allowing the two to go on together; but the State management is prin-

cipally confined to political lines, such as those on the north-west frontier, and in Burmah. In other cases lines are made and owned by the Government, but the policy has been to arrange for their being worked by companies.

This plan has been followed with the Rajputana-Malwa State line, which has been leased to the Bombay, Baroda, and Central Indian Railway Company, until June, 1900, on terms which secure to the Government 5 per cent. on the capital expended by them, and four-fifths of the profits besides. Certain State and provincial lines in the North-West Provinces and Oudh have also been transferred to companies to work. In Madras, too, the Kistna State Railway has been handed over to the Southern Mahratta Company, and the Nellore line to the South Indian, who are undertaking for the Government other lines in that Presidency, which are being made principally to protect the population in the districts through which they pass from the effects of famine.

I have alluded to the purchase of the East Indian Railway by the Government. This took place in 1880, at the end of the first term of the company's lease. Under the terms of the contract the shareholders received for every £100 stock an annuity for 75 years, equivalent in value to the £125, which was due to them, that being accepted as the average price of the stock for the three previous years. The capital value was £32,750,000, and the annuity came to £1,473,750, being at the rate of £5 12s. 6d. per cent. per annum. An arrangement was at the same time made with the company by which the payment of a fifth of the annuity was deferred for 50 years, subject to determination at the twentieth and any subsequent fifth year, and the management of the railway was left in the hands of the holders of stock equivalent thereto, viz., £6,550,000. Under the agreement thus made the holders thereof receive 4 per cent. and one-fifth of the net profits, after the annuity and all charges, including 4½ per cent. on the capital subsequently advanced by the Government for additional works and improvements, have been paid out of the earnings.

Since 1880, the net earnings have varied from Rs. 2,73,50,000 to Rs. 3,14,63,000 per annum, aggregating in eight years about Rs. 24,00,00,000. The company's share of profits have risen from Rs. 11,73,223 in 1884, to Rs. 15,87,252 in 1887, and the Government share from Rs. 2,59,00,000 to Rs. 2,63,49,000 per annum. The interest and annuity charges paid out of the railway earnings during that period has amounted to Rs. 16,98,76,151. By the year 1953, when the annuity will expire, the whole capital charge will have been paid off, and the line will have become the absolute property of the State without any further liability.

The Sind, Punjab, and Delhi Railways have also been purchased, as well as the Eastern Bengal and the Oudh and Rohilkund Railways. The first-named now form part of the great frontier system, which goes under the name of the North-Western Railway, and is managed as a State line. The Eastern Bengal and the Oudh and Rohilkund have also, for the present, been retained by the Government. The capital expenditure on the Sind, Punjab, and Delhi had been £11,075,319, and the Government paid a premium of £26 9s. 9d. per cent., bringing the total amount received by the Company up to £14,009,124. The share capital of the Eastern Bengal was £2,255,480, and the sum paid was £3,391,916, being a premium of £50 7s. 8½d. per cent.

Both sums were converted into annuities of £571,828 and £139,162 respectively, which expire in 1957 and 1958. But the shareholders of the Oudh and Rohilkund Railway were paid a sum of £5,036,048 in cash, the premium having been £25 18s. per cent., and the original share capital £4,000,000, the Government not having the option of paying by annuity computation.

A list of the other lines, now in the hands of companies, with the dates at which they may be purchased, is given on p. 463.

With regard to improvements in machinery and permanent way and to those due to new inventions of any kind, the Government, while ready to adopt the best that are produced for effecting efficiency and economy, generally like their value to be tested in a practical way, and look upon this country as the proper field for experiments. One cannot always apply the same method as the Duke of Wellington is said to have done on one occasion, when he tried the faith of a patentee who had persistently applied for his patronage. It was a patent for a shot-proof uniform. And the patentee having obtained an audience of the Field Marshal, asseverated his conviction of its efficiency. "Well," said the Duke, "I should like to see it. Will you put it on?" This being assented to, the Duke turned to his aide-de-camp and said, within the man's hearing, "have a file of soldiers ready in

COMPANIES UNDER CONTRACTS WITH THE GOVERNMENT.

Name of Company.	Earliest date for purchase.	Terms.
South Indian	Dec. 31, 1890	On the average price of the stock during the three preceding years.
Great Indian Peninsular	June 30, 1900	
Madras	Dec. 31, 1907	
Bombay, Baroda	Dec. 31, 1905	
Bengal, Central	June 30, 1905	Capital expended by company at par.
Indian, Midland	Dec. 31, 1910	
Bengal, Nagpur	Dec. 31, 1913	
Southern Mahratta	June 30, 1907	
Mysore	June 30, 1907	Capital of £1,200,000 which is not redeemable till March 1, 1936.
Bengal and North-Western	Dec. 31, 1912	Twenty-five times average net earnings during previous 5 years.
Rohilkund and Kumaon	Dec. 31, 1912	
Thaton Duyinzaik	Feb. 11, 1915	Value of property together with bonus of 25 per cent. on such value.*
Darjeeling Himalaya	July 4, 1906	Ditto. with bonus of 20 per cent.*
Deoghur	Dec. 23, 1912	Ditto. ditto.*
Dibru Sadiya	May 2, 1889	Ditto. ditto.*
Tarakeshwar	Jan. 1, 1915	Sum amounting to aggregate net profits during past twenty years.*
Delhi, Umballa, Kalka	Dec. 31, 1916	Twenty-five times average net earnings during previous five years.

* These lines can be purchased so many years after "date of opening." I have taken this as the date on which the last section was opened for traffic.

the yard with loaded muskets," and turning to the patentee said, "I will be with you in a few minutes." It need scarcely be added that the experiment was not tried.

There is not much need of any extraordinary brake power on most of the main lines; but on the Western Ghats and on the Bolan Railway and a few other places there are steep inclines, where trains must be furnished with the safeguard of a continuous automatic brake. The rivalry has been between the Westinghouse and vacuum brakes. Both have been tried in other countries, and both have been highly commended. Their respective advocates swear by each. Experiments with the two were tried in India last year; whether they were perfectly conclusive I am not prepared to say, but at present the vacuum seems to be the favourite there.

Indian railways, like many other institutions, have not escaped the cold water of doubt and pessimism during the various stages of their progress. Forty years ago, when all other arguments failed against their introduction into India, it was said by people of this school, "You may construct railways, but the natives will never use them." Twenty-five years ago a system of railways was considered complete which would form trunk lines of communication between Calcutta and the North-West, and join the three Presidency towns, and any proposal to construct more across the Continent was regarded as absurd. Later on, it was contended that the Government had done enough, and that the finances of the country could not bear any further liabilities on account of railways. And even now there are some people whose hearts fail them on the same ground. Fortunately, the ship of State has had at the helm men who were free from these forebodings and apprehensions, and who have pursued a bold but cautious policy, whereby the results we have been considering have been obtained. I venture to think that greater results still may be expected in the future, and that, with a due regard to the interests of the State in all arrangements for extensions, railways will be the sheet-anchor of Indian finance.

It has been seen that the railway earnings are at the rate of over five per cent. on the capital expended. When, however, those earnings are brought to England and converted into sterling, they are affected by the present

adverse rate of exchange. This loss, however, as the Select Committee of the House of Commons truly said, is "a matter outside the consideration of loss or profit," and does not alter the earning power of the railways. The loss has to be borne, for the most part, by the State, in consequence of interest having to be paid to those who have advanced money in England, where the relative value of gold and silver was very different to what it is now, and when the rate of exchange was fixed at 1s 10d. the rupee. This has no doubt seriously increased the charge upon the resources of the Government, and the fall in exchange is, on this account, much to be deplored.

The amount paid for interest appears, by the last Railway Report, to have exceeded the revenue derived by the Government from the lines, during the last thirty years, by £37,615,975, or an average of £1,253,859 per annum. The people of India have thus been taxed for the railways which now overspread the country. As the unfinished ones are completed, and become remunerative, it may be hoped that this loss will gradually diminish, and be turned into a gain. In the meanwhile, the effect of railways is to reduce other expenses to which the Government would be liable, to increase the land revenue, as well as the general wealth of the country, in which all participate—from the labourer, with his improved wages, to the cultivator and merchant, with their larger gains.

By the report for 1887-8, prepared by Colonel Conway Gordon, R.E., it appears that in 14,065 miles of open lines, with 1,998 stations, 225,047 persons were employed. Of these 215,286 were natives, 5,077 East Indians, and 4,684 Europeans; the natives being 95·66 per cent. of the whole. The native driver is yearly becoming more efficient, and is employed in increasing numbers. Upwards of 1,100 and shunters are so employed.

The Europeans, while comparatively small in numbers, have their wives with them, and the number of European souls have multiplied. It became, therefore, necessary to provide for the education and training of the young people, and, since 1877, schools have been established on the hills, in as good a climate as can be found for the growth of English muscle and sinew, and where the development of the intellectual and moral faculties is attended to, and religious instruction given. Hundreds of English children are thus educated.

Another advantage derived from railways is the migration, which before their time was impossible on any large scale, can now be carried out to the advantage of the province that gives and the province that takes. Assam is provided with labour from Bengal, and the same thing will occur in other parts of India; for notwithstanding the attachment of the peasant to his village, better wages and an improved condition will tempt him away, at any rate for a time, from his home, to till uncultivated land, and to be employed in new industries. Mr. Birkmyre, a manufacturer on an extensive scale in Calcutta, gave the Parliamentary Committee on Main Railways, in 1884, his practical experience on this point. He said that he employed upwards of 5,000 natives in his factories, and that many of them were migrants from up country. "Like any other nationality," he observed, "I have always found that if you give them an inducement in the way of employment, they will emigrate."

The ease with which a voyage to India can now be made, and the facilities for travelling in the country have, of late years, become so great that many visitors have been attracted to it. The number who go there from England increase yearly, and an excursion there is becoming almost as easy as trips to Switzerland, Italy, and other European countries. All this will do good. It will awaken a greater interest in Indian affairs, and will furnish the means of gaining an insight, although transitory, into the extraordinary character of the country and the peculiarities of the people. I have heard it said that some recent travellers have complained of the speed at which railway trains ordinarily run. They certainly do not go at the same rate at which passengers are taken by the express from London to Edinburgh; and probably when the timetables were prepared the habits and wants of the people of the country were thought of more than the requirements of those who, in slang phrase—and I use it without irreverence—are called "globe trotters." But there are now mail trains which run in communication with the mail steamers from Europe every week, and journeys may be performed by them at the rate of 40 miles an hour. The journey from Calcutta to Bombay, a distance of 1,400 miles by rail, is thus performed in 43 hours, including 1½ hours for meals. Starting from Calcutta on a Wednesday morning, the traveller arrives at Bombay on Friday afternoon before the mail starts for Europe.

I am glad to hear that Messrs. Cook and

Son, the great organisers of travelling expeditions all over the world, have not received any complaints from their numerous customers respecting the comfort of railway travelling in India. At any rate, I trust that, if sometimes English travellers have met with any discomfort, they have been carried with perfect safety, and have returned better and wiser for their trip. They will admit, I hope, that the management is upon the whole good, and that there is nothing in the list of accidents to shake the nerves of intending travellers. The average number of fatal accidents to passengers, during the five years ending 1887, was 1 in 14,000,000, and of injuries received about 1 in 1,500,000.

Trade.

To pass from railways to trade seems a natural transition. They are near akin to each other, and the interests of the two are interwoven. The present position of India is due to trade, for trade was the origin of British rule there. The East India Company endeavoured to confine itself to its original commercial objects, but, in spite of themselves and of their enemies, became, through their agents, rulers of an empire which their gains as a trading company helped them to govern. As monopolists they established trade centres, and Calcutta and Bombay, now rival queens in the domain of commerce, became two of the most important sea-ports of the world. The removal of the Company's monopoly, and the withdrawal of the differential duties which had been imposed to protect the Colonies, gave a fresh stimulus to trade, and, latterly, freedom from all vexatious import and export duties, the introduction of steam navigation, and the internal development of the country, has produced an expansion which the most vivid imagination of the most far-seeing director of the old East India Company could not have allowed himself to conceive.

Railways, no doubt, have had a very important share in producing the commercial prosperity of recent years, and the progress of trade has prospered railways. I do not wish to give them more than their due, but that they have done much, and will do more, cannot, I think, be disputed. Their effects on the productive resources of the country will be understood when it is borne in mind that communications now exist where there were no means of communication before, and that they have promoted cultivation, by the speed, safety, regularity, and cheapness with which the products of the soil are brought in good condition to the coast. The railway not only traverses plains, and spans broad rivers, but scales mountains, and invades the "forest primeval," which, under the clearing process, will become fit for the plough and harrow, providing food and employment for the increasing population.

Other agencies have, as I have said, been at work. The opening of the Suez Canal had a great effect; and the vast improvements made in steam navigation have also, by lessening the cost of transport, contributed their share. In his jubilee address to the Institution of Civil Engineers, Sir George Bruce, the present President, and our own worthy Chairman on this occasion, thus explains the economics which have been produced by recent improvements in marine machinery. "First, the screw-propeller, then the introduction of iron and steel in the building of ships, then the increase of pressure in the boiler, and the introduction of surface-condensers, followed by the use of compound and triplicate expansion cylinders, and a much larger increase in boiler pressure, rendered possible by the use of mild steel in the construction of the boilers, effecting in all a reduction of at least 70 per cent. in the consumption of coal per indicated horse-power, and an increase of 110 per cent. in speed."

Another cause I may mention, although there are great differences of opinion upon it, is the fall in the value of silver compared with gold. The report of the Royal Commission on the recent changes in the relative values of the precious metals shows what divergent ideas there are on the subject. For every opinion given in support of one view, another is furnished on the other side, and there the committee leaves the question, probably six thinking one way and half-a-dozen the other. This is not the occasion to go into so difficult and abstruse a subject. But I venture to think that, up to this time, the effect of the low price of silver has been to aid the expansion of the trade of India; and that, so long as prices in India remain unaffected, and prices in Europe continue high enough to leave a margin for profit, the export of goods must be stimulated. But while an impulse is thus given to exports, imports have, from the same and other causes, increased in a larger ratio. Mr. O'Conor tells us that in ten years imports have increased nearly 75 per cent., while exports have increased only 42 per cent.

Whether the present rate of exchange will encourage the application of private enterprise to public works in India is another question; for unless the reduced cost of executing works by means of English gold is sufficient to counteract the effect of converting the silver earnings into sterling, such enterprise will receive a check.

As an example of the sympathy between trade and railway, we may take the year 1878-9, when trade suffered in consequence of the famine. In round numbers the value of merchandise imported was (in tens of rupees) 37,800,000, compared with 41,464,000 in the previous year, and the exports 60,937,000, compared with 65,222,000; and, notwithstanding that there was a large movement of grain on the railways to provide food for the famine-stricken districts, the traffic fell from 8,000,000 to 7,000,000 tons, and the net receipts from £6,248,000 to £5,197,000. The diminished returns were entirely on the side of merchandise, the passenger traffic having shown an increase. Again, in 1884, similar results were produced, the value of exports being less than the previous year by £5,000,000, and the revenue from the railways about £500,000.

It is now time that I should show the actual progress which has been made in the trade of India during the last few years. Tabulated statements are given at the end of the paper, but to give you a general idea I may state that the total export and import trade has increased in value from (tens of rupees) 92,581,354 in 1874-5, to 155,558,267 in 1887-8. In 1874-5 the imports amounted to Rx. 36,222,113; in 1887-8 to Rx. 65,004,612, and the exports to Rx. 56,359,241 and Rx. 90,543,655 respectively. The only unsatisfactory feature, so far as England is concerned, is that there is an apparent diversion of the trade from the United Kingdom to other countries, the proportion of the whole imports from England in 1874-5 being 83·4 per cent.; in 1887-8, 76·5; and of exports, 49·0 and 38·7 per cent. respectively. Not that the trade with this country has decreased, for it has enlarged considerably, the imports into India from the United Kingdom having been Rx. 30,200,000 in 1874-5, and Rx. 51,600,000 in 1887; and the exports Rx. 27,600,000 and Rx. 35,000,000. Other countries have probably become alive to the value of direct communication, and do not use England as an entrepôt, as they did before the Suez Canal was opened. India has no reason to be dissatisfied, for the more numerous her markets the better she should be pleased. "Trade too, like blood, should circularly flow." Her imports from other places in Europe than the United Kingdom in 1874-5 were to the value of Rx. 715,585. In 1887-8 they were Rx. 2,540,314. The exports had increased in the same period from Rx. 7,515,838 to Rx. 20,314,071. The trade with France has, for example, increased from Rx. 6,410,737 in 1877-8, to Rx. 8,058,917 in 1887-8. Imports increased from Rx. 451,000 to Rx. 849,000, and exports from Rx. 5,969,000 to Rx. 7,209,000. So with Italy, the exports increased in the same period from Rx. 1,870,000 to Rx. 4,527,000, and the imports from Rx. 2,219,000 to Rx. 4,898,000. With the United States the increase has been in greater proportion. In 1877-8 the exports from India were Rx. 1,932,000, and in 1887-8 Rx. 3,782,000, the imports being Rx. 279,717 and Rx. 1,030,280 respectively. Nor is it surprising that in some cases England should find her great dependency a competitor with her in certain of her old markets for the supply of particular commodities. India is becoming a manufacturing country, and having the raw material on the spot, with as good machinery as can be obtained, and cheap labour into the bargain, she is likely to increase her trade in manufactures. The cotton mills alone have increased from 47 in 1876 to 94 in 1886. English capital has been invested in manufactories in Calcutta and Bombay, and some establishments have been transferred there from Manchester and Dundee. Mr. Birkmyre told the Parliamentary Committee that he had removed the whole of his establishment and the necessary machinery from Scotland to set up his manufactory in Calcutta. We thus understand how the natural advantages of locality, aided by skilled management, have largely increased the exports to China and Japan, and, I may add, Eastern Africa, of just those description of goods which those countries require. In 1883-4 about 41,000,000 lbs. of twist were exported to China. In 1887-8 the quantity had increased to 92,500,000. Piece goods in 1883-4 amounted to 2,147,000 yards, and in 1887-8 to 4,484,000. The increase in the export of some of the most important articles of native manufacture was as follows, comparing 1877 with 1887:—Cotton twist, 497 per cent.; cotton manufactures, 149 per cent.; jute, 126 per cent.; silk, 151 per cent. The total value of exports to China increased in the five years, between 1874-5 and

1879-80, from Rx. 11,648,189 to Rx. 15,523,678, but in 1887-8 they were reduced to Rx. 13,092,000. Trade with Japan increased from Rx. 3,049,000 in 1883-4 to Rx. 7,462,000 in 1887. The value of cotton twist and yarn exported to Japan increased from Rx. 7,821 in 1879, to Rx. 678,000 in 1887, and gunny bags from Rx. 7,750 in 1884-5, to Rx. 21,336 in 1888. Trade with Australia appears also steadily to have increased. In 1874-5, the exports were valued at Rx. 135,486. In 1887-8, Rx. 1,125,025. And yet, with all this activity in other directions than the United Kingdom, the proportion which imports from Great Britain bear to the rest has not very materially changed. In 1874-5 they were, as I have already stated, 83·4 per cent., and in 1887-8, 79·5 per cent. of the whole. The value of cotton piece goods imported from Great Britain was Rx. 13,697,492 in 1874-5, and Rx. 22,982,858 in 1887-8. Silk piece goods increased also from Rx. 344,072 to Rx. 717,982. Tables at the end of the paper furnish further particulars. There are some apparent anomalies in connection with Indian trade, which, with the help of Mr. O'Conor's very interesting annual reports, are not very difficult to account for. Take sugar for instance. One would as soon expect coal to be taken to Newcastle as sugar to India; and yet the importation is increasing and the export diminishing. The former increased from 736,900 cwt. in 1883-4 to 1,808,400 in 1887; while exports fell in the same period from 1,630,520 cwt. to 1,046,200 cwt. This state of the trade is attributed by Mr. O'Conor to the competition of Continental beet-root sugar, protected by bounties, and to the overstocked market for cane sugar in Europe. Tea, also, while it is largely exported, is, at the same time, imported. Bombay imported last year about 3,623,800 lbs. The export of tea has, however, made great strides, and is gradually superseding Chinese tea in the English market. I can recollect the time when samples of tea from gardens in India were considered a curiosity. The Government in those days were the sole cultivators, and were the pioneers, as they have been in quinine, and other products. Thirty years ago the amount of tea exported was very insignificant. A decided start was made in 1869-70, when 12,754,000 lbs. were exported almost entirely to the United Kingdom. In 1880, it was 38,174,500 lbs.; and in 1887-88, the total quantity had increased to 87,514,500 lbs., of the value of Rs. 5,174,440. In 1880, the quantity imported from China into the United Kingdom was 158,032,100 lbs., and in 1887, 110,849,258 lbs. The export of the Cinchona bark has risen from 26,992 lbs. in 1874, to 1,449,313 lbs. in 1887-88.

Vegetable oil is also imported, while the raw material is produced in the country, and, as Mr. O'Conor says, there is every facility for its manufacture. Last year 800,000 gallons were imported. Mineral oil has become lately a very important item in the trade returns. It appears to have superseded the vegetable oils for lighting purposes, simply because it is cheaper, and because the oil seeds can be put to more profitable account. The imports are now very large. Last year 31 million gallons came from the United States and Russia, of the value of Rx. 1,274,000. Twelve years ago the value was Rx. 79,000. While we received last year upwards of five million gallons from Asiatic Russia, the prohibitive tariffs of Russia exclude British and Indian goods from the markets of that part of the world.

This is the effect of railways, but different results will, I expect, before long, be produced by the same means, for railways are taken into districts where Indian petroleum can be supplied. In Burma, the Punjab, and Beloochistan, large deposits have been found, and are already used on the railways, and have been brought to the market. The same process will take place with coal. Various new fields have been opened up by railways. The facilities of cheap transport thus afforded will, it is hoped, help to reduce the high cost of fuel which now prevails on many lines, and diminish the large quantity imported. During the year 1887, 691,739 tons were used on the railways, of which 212,529 were brought from England, and supplied to the railways at a cost varying from Rs. 11 to Rs. 20 a ton. The average cost on the East Indian Railway, which has its own native coal, was Rs. 2·18 per ton.

There is one article which it is rather surprising to see largely imported, and that is the umbrella. Last year 3,218,440 were received from England, and 1,460,316 from China. I do not mean that umbrellas are not wanted, for they are no doubt required to serve the double purpose of the parasol and parapluie in India, but it is curious that India herself should not have found means of supplying her own wants.

I might enlarge on the trade in some commodities which of late years have aided to augment the commerce of the country, such as jute, both in its raw and manufactured state,

silk, tobacco, cinchona, rhea, &c.; but time will not permit me to do so, and I must be content to draw your attention to one remarkable feature of modern trade. Thirty years ago, Indian wheat was not known in this country. It is now regarded as an important and reliable part of the food supplies of our population. It has also, I believe, from its properties, become a valuable element in improving the quality of other wheat for baking purposes. It will be seen by the accompanying Table, that in the year 1874-5 the total quantity exported from India was 1,069,076 cwt., of the value of Rx. 490,435; that ten years after, in 1884-5, the amount was 15,831,753 cwt., of the value of Rx. 6,309,140. In 1885-6, the quantity rose to 21,060,519 cwt., and in 1886-7 was 22,263,320; but in 1887-8 it fell to 13,538,169. Fluctuations will of course occur, according to the price in the English market, the demand for grain in India in case of scarcity in any part of the country, and the power of rival countries to supply England at a lower price than would pay the Indian cultivator and merchant. The United States, Canada, and Russia are the chief competitors, and in 1885, when 36 million cwts. were imported into England from the United States, India and Russia each sent about 12 millions. The supplies from India have varied from 11 to 15 per cent. of the whole imports into England. It will be observed that, while a large proportion of that exported goes to England, a considerable part finds its way to other European countries, In 1879-80, 74 per cent. of the whole went to England, and only 5·9 to other places in Europe; but in 1887-88 only 44·6 was exported to England, and 48·6 to other countries.

The character that India has of absorbing the precious metals is well known. The amounts of hoardings which are applied to no profitable purpose must be enormous, and the habit of burying gold and silver, or of converting them into ornaments, does not seem to diminish with the spread of education, or the advance in prosperity. Taking the last ten years, from 1878-79 to 1887-88, we find that during the first five, Rs. 14,284,385 gold and Rs. 28,598,288 of silver, and during the next five years, Rs. 18,066,923, and Rs. 41,642,903 were imported.

The trade of India has, I believe, expanded within the last ten years more than any other country; and I will conclude this part of the subject by showing in the following table the increase or decrease in the exports of the principal articles produced and manufactured in India, by comparing the year 1878-8 with 1887-8.

Increase or Decrease in Exports of principal articles in 1887-8, *as compared with* 1877-8.

INCREASE.

Article.	Amouat of increase.	Increase per cent.
	Rx.	
Cotton twist and yarn......	3,395,328	497·8
Cotton manufactures	689,868	149·7
Jute ,, ...	975,233	126·5
Silk ,, ...	228,216	151·0
Raw cotton	5,029,308	53·6
,, jute	2,522,265	71·7
,, wool	28,701	3·0
Indigo....................	396,315	11.3
Dyes (other than indigo) ..	202,981	34·4
Lac (excluding dye)	168,229	50·5
Hides and skins	1,095,495	29·1
Seeds	2,024,740	27·5
Tobacco	36,415	39·1
Grain and pulse :—		
Wheat	2,705,383	94·7
Rice	2,335,747	33·9
Other sorts..............	365,243	94·2
Tea	2,129,869	70.0
Coffee	191,181	14·2
Spices	295,043	130·2
Provisions	327,537	161·3
Drugs and medicines	137,491	164·8
Oils	99,503	26·8
Gums and resins	174,567	188·0

DECREASE.

Article.	Amount of decrease.	Decrease per cent
	Rs.	
Woollen manufactures	93,815	45·1
Raw silk..................	222,738	31·6
Sugar	280,022	37·5
Opium...............	1,079,895	8·7
Teak timber	39,378	9·6
Saltpetre................	14.986	4·0
Horns	29,807	15·3

I hope I have said enough to justify the use of the term "progress" which has been used in the title of this paper. This is not the place, nor the occasion, to discuss the various problems of Indian Government or Indian society;

I.—Total Sea-borne Trade of India (including Treasure).

Imports.

Year.	United Kingdom.		Other countries.		Total.
	Amount.	Proportion of total.	Amount.	Proportion of total.	
	Rx.	Per cent.	Rx.	Per cent.	Rx.
1874-75 ..	30,227,215	83·4	5,994,898	16 6	36,222,113
1879-80 ..	33,424,147	81·2	7,744,769	18·8	41,168,916
1884-85 ..	44,687,748	80·2	11,015,324	19 8	55,703,072
1887-88 ..	51,650,627	79·5	13,353,985	20·5	65,004,612

Exports.

Year.	United Kingdom Amount.	Proportion of total.	Other countries Amount.	Proportion of total.	Total.
1874-75 ..	27,601,868	49·0	28,757,373	51·0	56,359,241
1879-80 ..	27,415,175	40·8	39,797,188	59·2	67,212,363
1884-85 ..	33,646,890	40·4	49,608,402	59·6	83,255,292
1887-88 ..	35,058,574	38·7	55,485,081	61·3	90,543,655

II.—Trade with Europe (outside the United Kingdom), China, and Australia.

Imports.

Year.	Europe (other than United Kingdom).		China (Hong-Kong & Treaty Ports).		Australasia.	
	Amount.	Proportion of total.	Amount.	Proportion of total.	Amount.	Proportion of total.
	Rx.	Per cent.	Rx.	Per cent.	Rx.	Per cent.
1874-75 ..	715,585	2·0	1,520,175	4·2	183,234	0·5
1879-80 ..	1,100,220	2·7	1,579,075	3·8	244,375	0·6
1884-85 ..	1,865,946	3·3	1,865,725	3·3	465,374	0·8
1887-88 ..	2,540,314	3·9	2,415,321	3·7	484,885	0·7

Exports.

Year.	Europe Amount.	Proportion of total.	China Amount.	Proportion of total.	Australasia Amount.	Proportion of total.
1874-75 ..	7,515,838	13·3	11,648,189	20·7	135,486	0·2
1879-80 ..	9,820,388	14·6	15,523,678	23·1	459,921	0·7
1884-85 ..	18,993,277	22·8	12.564,636	15·1	784,270	0·9
1887-88 ..	20,314,071	22·4	13,092,101	14·5	1,125,025	1·2

III.—Number and Tonnage of Ships Registered at Indian Ports.

Year.	From and to United Kingdom.				From and to other countries.				Total.	
	No.	Tonnage.	Proportion of total number.	Proportion of total tonnage.	No.	Tonnage.	Proportion of total number.	Proportion of total tonnage.	No.	Tonnage.
			Per cent.	Per cent.			Per cent.	Per cent.		
1874-75	2,080	2,340,007	16·7	48·5	10,357	2,485,535	83·3	51·5	12,437	4,825,542
1879-80	1,890	2,586,893	15·6	45·4	10,266	3,111,162	84·4	54·6	12,156	5.698,055
1884-85	1 804	2,908,987	17·5	43·7	8,524	3,740,083	82·5	56·3	10,328	6,649,070
1887-88	1,796	3,085,130	16·5	42·9	9,097	4,104,335	83·5	57·1	10,893	7,189,465

IV.—Exports of Wheat, Seeds, Jute, Cotton, and Tea.

1.—*Wheat.*

Year.	Total Quantity.	Total Value.	Proportion to United Kingdom.	Proportion to other European countries.
	Cwts.	Rx.	Per cent.	Per cent.
1874-75	1,069,076	490,435	37·4	38 8
1879-80	2,195,550	1,121,015	74·1	5·9
1884-85	15,831,754	6,309,140	47·0	38·4
1887-88	13,538,169*	5,562,373	44·6	48·6

2.—*Seeds.*

Year.	Total Quantity.	Total Value.	Proportion to United Kingdom.	Proportion to other European countries.
	Cwts.	Rx.	Per cent.	Per cent.
1874-75	6,074,756	3,235,947	44·4	21·3
1879-80	7,091,469	4,685,892	46·1	41·7
1884-85	18,250,688	10,745,203	39·3	50·0
1887-88	16,060,400	9,385,024	39·0	53·2

3.—*Jute* (*raw*).

Year.	Total Quantity.	Total Value.	Proportion to United Kingdom.	Proportion to other European countries.
	Cwts.	Rx.	Per cent.	Per cent.
1849-50	——†	88,989	——†	——†
1859-60	761,201	290,018	89·8	——†
1869-70	3,361,852	1,984,495	88·3	1·6
1879-80	6,680,670	4,370,032	73·0	3·4
1887-88	9,643,484	6,040,379	65·5	10·2

4.—*Cotton* (*raw*).

Year.	Total Quantity.	Total Value.	Proportion to United Kingdom.	Proportion to other European countries.
	lbs.	Rx.	Per cent.	Per cent.
1849-50	——†	2,201,178	——†	——†
1859-60	345,953,569	5,637,624	69·0	——†
1869-70	554,834,522	19,079,138	79·2	13·7
1879-80	442,229,312	11,145,453	48·1	43·4
1887-88	601,948,704	14,412,842	39·8	55·5

5.—*Tea.*

Year.	Total Quantity.	Total Value.	Proportion to United Kingdom.	Proportion to other European countries.
	lbs.	Rx.	Per cent.	Per cent.
1849-50	——†	27,231	——†	——†
1859-60	——†	127,771	——†	——†
1869-70	12,754,022	1,037,883	99·4	0·02
1879-80	38,174,521	3,051,020	99·4	0·02
1887-88	87,514,505	5,174,440	96·2	0·06

* In 1886-7, the quantity was 22,263,320 cwts.; in 1885-6, 21,060,519 cwts. † Information not given.

IV (*a*).—Imports and Exports of Mineral Oils (Petroleum, &c.).

Year.	Imports.*		Exports.†	
	Quantity.	Value.	Quantity.	Values.
	Gallons.	Rx.	Gallons.	Rx.
1874-75	—	79,807	9,970	635
1879-80	7,888,247	481,908	19,245	1,447
1884-85	27,306,999	1,158,222	30,502	2,716
1887-88	31,421,559	1,274,476	9,249	1,658

* The oil imported came almost entirely from the United States, till 1887-8, in which year 5,035,782 gallons, valued at Rs. 227,244, came from Russia in Asia (25,038,620 gals. from United States).

† The figures given as "Exports" refer only to Indian produce. A considerable trade is done in foreign oil sent to India, and re-exported thence to neighbouring countries (Turkey in Asia, Persia, Arabia, Zanzibar, &c.). The amount of this trade in the above years was as follows:—

1879-80	247,905 gallons	Rx. 13,942
1884-85	703,310 ,, ...	Rx. 29,994
1887-88	358,715 ,, ...	Rx. 16,708

V.—Imports of certain articles from the United Kingdom.

Article.	1874-75.		1879-80.		1884-85.		1887-88.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Piece Goods—	Yards.	Rx.	Yards.	Rx.	Yards.	Rx.	Yards.	Rx.
Cotton	1,007,422,820	13,697,492	1,320,213,439	16,330,993	1,722,464,735	20,502,276	1,827,800,346	22,982,858
Silk...........................	2,371,207	344,072	2,539,765	335,933	5,233,698	504,487	5,684,085	717,952
Total piece goods	1,009,794,027	14,041,564	1,322,753,204	16,666,926	1,727,698,433	21,006,763	1,833,484,431	23,700,800
Twist and Yarn	lbs. 36,392,630	3,080,322	lbs. 32,609,696	2,679,597	lbs. 43,838,776	3,272,438	lbs. 50,729,084	3,516,857
Woollen Goods—								
Piece goods..............	... †	... †	Yards. 7,971,882	793,693	Yards. 10,953,467	1,051,560	Yards. 12,993,873	1,323,440
Shawls	... †	... †	No. 446,283	92,178	No. 453,361	93,304	No. 490,084	88,903
Total woollen goods...	... †	523,504	...	885,871	...	1,144,864	...	1,422,343
Coal (including coke and patent fuel).......	Tons. 355,652	683,767	Tons. 531,413	1,030,126	Tons. 727,895	1,244,579	Tons. 848,291	1,675,110
Machinery and Mill-work (excluding railway rolling stock)	...	1,177,437	...	633,226	...	1,563,752	...	1,830,598
*Hardware and Cutlery** (including plated goods)	...	(268,907)‡	...	459,783	...	857,263	...	1,067,891

* The returns do not give "iron and steel manufactures" separately, except for 1874-5. † Particulars not given.
‡ Iron and steel manufactures.

VI.—Importation of Tea into the United Kingdom from China and Hong-Kong.

Year.	Quantity.	Value.
	lbs.	£
1875	169,762,945	11,408,053
1880..................................	158,032,111	8,341,074
1885..................................	139,588,183	6,448,277
1887*	118,849,258	4,603,988

* Information for 1888 not yet available.

VII.—Exports of Indian Manufactures to Japan.

Article.	1887-8.		1884 5		1879-80.	
	Quantity,	Value.	Quantity.	Value.	Quantity.	Value.
Cotton—		Rx.		Rx.		Rx.
Twist and yarn	17,391,646 lbs.	678,010	6,943,680 lbs.	265,027	1,814,090 lbs.	78,826
Piece goods ..	37,560 yds.	530	36,261 yds.	546	72,000 yds.	1,050
Jute—						
Raw	4,124 cwts.	2,759	—	—	—	—
Gunny-bags ..	928,880	21,336	526,064	7,754	—	—

The export of gunny-bags commenced in 1882-3, when 65,400, worth Rs. 1664, were exported.

VIII.—Number and Tonnage of Ships which entered the ports in Bengal, Madras, Bombay, and Sind, respectively, in 1867-8, 1877-8, and 1887-8.

Province.	1867-8.		1877-8.		1887-8.	
	Number.	Tonnage.	Number.	Tonnage.	Number.	Tonnage.
Bengal	764	710,300	861	1,010,069	604	856,039
Madras	3,107*	453,703	3,392*	534,033	2,607*	671,954
Bombay	1,280 (Bombay and Sind)	641,232 (Bombay and Sind)	1,096	801,580	1,096	1,191,950
Sind.....................			364	101,754	455	229,482

* Principally "native craft."

IX.—Trade between India and China, France, Italy, and the United States, in 1877-8, and 1887-8.

Country.	1887-8.				1877-8.			
	Imports.		Exports.		Imports.		Exports.	
	Value.	Per-cent-age on total Indian imports.	Value.	Per-cent-age on total Indian exports.	Value.	Per-cent-age on total Indian imports.	Value.	Per-cent-age on total Indian exports.
	Rx.		Rx.		Rx.		Rx.	
China (Hong-Kong & Treaty Ports)	2,415,321	3·7	13,092,101	14 5	1,423,673	3·4	12,743,152	19·5
France	849,091	1·3	7,209,826	8·0	451,130	1·1	5,967,607	9·1
Italy	371,073*	0·6	4,527,546	5·0	349,489	0·8	1,870,006	2 9
Egypt....................................	72,407	0·1	3,238,839	3·6	42,462	0·1	577,955	0·9
United States....................	1,030,280	1·6	3,782,737	4·2	279,717	0·7	1,932,728	3·0

* Less than in any year since 1877-8. The average for the eight years, 1879-87, was Rx. 471,480.

X.—Net Imports of Treasure, 1878-88.

	Gold.	Silver.		Gold.	Silver.
	Rx.	Rx.		Rx.	Rx.
1878-79	896,173	3,970,694	1883-84	5,462,505	6,406,154
1879-80	1,750,504	7,869,743	1884-85	4,671,937	7,245,631
1880-81	3,665,199	3,892,574	1885-86	2,762,935	11,606,629
1881-82	4,843,984	5,379,050	1886-87	2,177,065	7,155,738
1882-83	4,930,872	7,486,227	1887-88	2,992,481	9,228,751
	14,284,386	28,598,288		18,066,923	41,642,903

XI.—Share of Each Province in the Movement of Ships with Cargoes.

Province.	1887-8.			1877-8.		
	Number of Ships.	Gross Tonnage.	Average Tonnage per vessel.	Number of Ships.	Gross Tonnage.	Average Tonnage per vessel.
Bengal	1,147	1,683,421	1,468	1,539	1,820,524	1,183
Bombay	2,027	2,142,791	1,057	1,877	1,349,444	720
Sind	795	363,892	458	643	205,644	320
Madras	3,692*	1,200,274	325	3,457*	809,092	234
Burma	1,003	1,045,425	1,042	992	676,460	682

* Mostly small native craft.

but there is one problem which I venture to think has been solved, and that is, that railways have been a most important factor in promoting the commerce, the civilisation, and the material prosperity of the country. The British connection with India has done much for the people. Security, peace, justice, liberty have been established; the abolition of barbarous practices has been effected; women and children have been protected, and a system of education has been introduced. Some of these blessings have been imposed upon unwilling recipients, but railways stand out as one of those benefits which is accepted and used as an unmixed good by all classes, high as well as low.

At the commencement of the paper I quoted the words of the late respected Viceroy, spoken on the eve of his departure from India. I will now close by a quotation from a speech of his successor, the Marquis of Lansdowne, delivered on his arrival in the country. The one was the result of experience and thoughtful deliberation, the other is full of hope and promise for the future, especially as regards the subject we have been considering. "I feel," said Lord Lansdowne, "that at the present time all proposals involving an increase of the public expenditure requires the closest examination and scrutiny. There is, nevertheless, I am convinced, no duty more incumbent upon the Government than that of extending the railway communication of the country, and of bringing to light and rendering available for human use the wealth which is latent within it. Nor is there, I believe, any chapter of Indian history to which we have a right to recur with greater satisfaction than that which records our past achievements in this direction, achievements the progress of which will, I trust, not be arrested during my connection with the Government."

DISCUSSION.

Mr. Holt Hallett said he had just returned from Lancashire, where he had found great interest taken by the people in the question of opening out India by the development of its railways. In the report issued by the Royal Commission in January, 1887, after showing how foreign nations were competing with us in every direction, British trade being blocked out from one market after another by protective tariffs, and also injured by the lamentable state of agriculture, the Commissioners came to the conclusion that new markets were required for British trade. Witness after witness, representing both chambers of commerce and operative societies, brought to the notice of the Commissioners that India and China were the two markets in which to seek for the extension of trade. Since then more markets had been closed against us; our trade in cotton piece goods with European markets had decreased one-tenth, and with North America 23 per cent., and it was natural therefore that the operatives of Lancashire should be looking to the greatest market in the world, India, which took 35 per cent. of the cotton piece goods of Lancashire. Whilst losing trade with the rest of the world, our trade with India had increased during the last ten years 66 per cent., and with China 35 per cent. The excuse of the Government for not further extending the railway system in India was the financial difficulty, and it was said they could not impose more taxation on the people; but in the last years the Government revenue had increased by 83,000,000 rupees, which was chiefly owing to the railways, and that was at least four times the present yearly loss on the railways. In 1882, Mr. Barbour, financial secretary to the Government, reported that the average earnings of the natives were 27 rupees a year, but from a table appended to the report of the Gold and Silver Commission, it appeared that the wages of common labourers at different railway stations in India were more than double that. It was therefore the Government which was keeping the natives poor by not constructing more railways, which were not only valuable in opening up trade with this country, but also in developing internal trade. There were now 15,000 miles of railway in India, but they were so distributed that four-fifths of the area of the country had barely 4,000 miles of railway, and, in fact, hardly the fringe of the population had as yet been brought within their influence.

Sir Bradford Leslie agreed with the last speaker as to the importance of railways to the people of India, and thought there was room for an immediate extension of about 5,000 miles, which could be made much more cheaply now than formerly, and would therefore be more likely to prove remunerative.

Sir A. J. Leppoc Cappel also agreed with Sir Juland Danvers that railways were of great benefit to India, and that the more they were extended the better.

Mr. Ernest Walford thought everyone would agree that railways had been already a great boon to India, and would become a still greater boon in the future. The great question was, how were they to be constructed as cheaply as possible. His attention had been mainly given to the financial side of the question, and he would remark that whilst the embarrassment of the Indian Government was mainly due to the loss on exchange, every additional guaranteed railway must further augment that difficulty. They could not blame the Government, then, for not guaranteeing more railways. It was undoubtedly their duty to encourage the construction of railways, but the policy pursued at present had exactly the opposite effect. On turning to the Blue-book, it would be found that there were some State railways which earned merely nominal sums, whilst others gave returns varying from 3 to 6 per cent. The system in force was this. As soon as a lease terminated, the Government took over the line and handed it to the State railway department, who generally mismanaged it, paying off the shareholders either in cash or by annuities; and it did not appear that the State management was successful, judging by an article in the *Engineer* in March of last year, which referred to the unpunctuality and accidents on the Eastern Bengal line, and he said that it had been so mismanaged that, instead of earning 12 per cent., as it did when worked by the late company, it now only earned about 4 per cent. The great thing to aim at was to encourage the public to invest their money in railways in India as they did in other parts of the world without a guarantee, and he would suggest that the best way to do that would be to sell the Government railways, which were paying from 3 to 6 per cent., at 25 years' purchase, and with the proceeds redeem part of the sterling debt. When that had been done with two or three lines, the public would become accustomed to invest in Indian railways without a guarantee, and would go on and construct more. Every additional railway constructed in India on this plan would tend to relieve the loss on the exchange.

General Shaw Stewart had listened to the paper with great interest, and agreed with it in every respect. There were many parts of India still unprovided with railways, where they were urgently required, and where they would be remunerative, both to the country and the Government.

General Maclagan also expressed his concurrence in the views set forth in the paper.

Mr. W. Martin Wood said the paper was rather optimistic in tone, so it was as well to remind the meeting that there was another side to the matter. Everyone agreed that railways had been a

great advantage in opening out India; but it was a question whether there were not other means required to supplement the railways, and which were, in some respects, more suited to the long distances and arid wastes of India. In speaking of the large area which was still unserved by railways, it must be remembered that that part of the country was, to a large extent, unsuited to their construction. Whilst £180,000,000 had been spent on railways, no more than £30,000,000 had been spent on water and water communication. Railways could not increase the produce of the country, but could only carry it when it was produced, whereas water would do both. Sir Juland Danvers had reminded them that railways did not actually pay the Indian Exchequer, but he had not mentioned the figures. In the year just closed, the estimated loss was upwards of 2,000,000 of tens of rupees; and that was only the loss on the surface. The interest on the old debt accumulated whilst the railways were being made, though not shown in the accounts, was none the less a charge on the finances of the country. This was a dead weight upon the commercial part of the system, now largely increased by the enormous expenditure on what were called the frontier railways, the majority of which, and the most costly part, were beyond the natural frontiers of India, and never could be expected to pay even their working expenses. Something had been said about their tendency to increase the attention paid by the natives to agricultural pursuits; but how that could be expected to operate in the wastes of Afghanistan and the rocks of Beluchistan was not very clear. It was very encouraging to find that latterly there had been much greater economy in the construction of Indian railways; this, he thought, was due in great measure to the larger proportion of metre-gauge railways during the later period, which were in some respects better suited to the long distances and sparse population. But of late years there had been a reaction against that economical method of construction, which was rather detrimental to the prospects of increased railway extension. For instance, on the Bengal and Nagpur railway the metre-gauge had been torn up, and the broad gauge laid down at an enormously increased expense. Sufficient attention had hardly been paid to the most obviously required routes; mention had been made of two or three railways which ran parallel to the coast; but it must be familiar to engineers that those railways which paid best, especially where there was a foreign trade, were those which ran transversely to the coast. Whilst they would all rejoice to see railways extended, they should remember at whose cost it was done, and see that each particular project was carefully examined before it was undertaken.

Mr. W. S. Seton-Karr remarked that Sir Juland Danvers's opinion on this question was valuable, inasmuch as he had practical observation of the solid and tangible difficulties to be encountered, though his knowledge of the subject had been mainly gained in this country. He (Mr. Seton-Karr) happened to have written the letter to the first Commissioner appointed to go over the land on which the first sod was turned for the East Indian Railway, in the time of Lord Dalhousie. When that railway was opened, an old Brahmin, on taking his seat in a carriage one morning, made a remark which he thought was worth repeating, as showing the opinion of a native of the old school. He said, "Surely to these men God has given the dominion; Indra (the rain god) has no chariot like this." The development of railroads in India had caused a great increase of ordinary roads, and had brought much more traffic into Calcutta, both by road, rail, and river, than ever came before. He had seen, in Sir William Hunter's interesting gazetteer, that no less than ten millions worth of produce were brought into Calcutta by river and canal, and three or four millions by railway. He was amused to hear of the large importation of umbrellas into India; but, for his own part, he should much prefer a common quilted native chattar, as a protection from the sun, to the best European umbrella he had ever seen. He was glad to hear that factories were at work in Bombay, and thought this fact would have a decided influence on the operations of Manchester manufacturers. Some gentlemen had blamed the Government for giving any guarantees; but if it had not been for the guarantees given by Sir Charles Wood in the time of Lord Dalhousie, there would not have been a single line made up to the time of the Mutiny. The statesmanlike views adopted by Lord Dalhousie and Sir Charles Wood, and followed by subsequent advisers to the Secretaries of State, had been the means of conferring incalculable benefits on India. Either regarding railways as part of the national system of defence, or as instruments for developing commerce and agriculture, the great debt owing to those two statesmen should never be forgotten.

Mr. Wilde said it seemed to be rather implied by some speakers that the extension of railways would increase the difficulty of the Government in the loss on the rupee, but it must be remembered that all the stores which were sent out were paid for at the exchange of the day, so that in that respect it made no difference. Without going too much into the disputed question about the change of gauge, he would say that an objection to the different lines was the break of gauge, and not the cost of construction. At the Institution of Civil Engineers, the other night, it was stated that the Government Comissioners said the maximum difference in cost was only £500 a mile, after allowing for the increased quantity of rolling stock required for working the narrow gauge with the same amount of traffic. If that were so, the saving of the metre gauge was not so very great, whilst the break of gauge was a very great objection, especially on the main traffic lines.

Mr. H. Kimber, M.P., remarked that very frequently great facts were not appreciated by the mind unless they were brought into comparison with others of a similar character. The railway system of India consisted of 15,000 miles, in a country containing at least 150,000,000, whereas in the United States of America there were 115,000 miles of railway to supply the wants of 60,000,000 of people at the outside, so that the contrast was very remarkable, and one could not but ask why there was this great difference. In India the people were more closely packed together than in America, except in certain portions, and labour was far cheaper, although the mileage cost of railways in America was, in many instances, not more than half that of some of the Indian railways. It was quite true that a great deal of that was attributable to the bad character of some of the American railways, for there was no doubt they killed more people on the American lines than on any other system in the world. When travelling there for a fortnight almost continuously, he was frequently awoke in the middle of the night by a jump of about twelve inches from the rails; but they risked all that for the sake of accomplishing the end in view. They were determined to have railways, although some had been described as consisting of two streaks of rust and a right of way. It seemed astonishing that with a population of 150,000,000 in India they could not make 15,000 miles of railway pay a fair interest, whilst in America they thought it worth while, with 115,000 miles still in existence, though it must be admitted some did not pay, to go on building at the rate of 9,000 or 10,000 miles per annum. The value of a railway to a country was not to be measured by the rate per cent. which the traffic gave on the cost, and he ventured to think that India prospered by the making of railways in a measure far exceeding anything which could be obtained by considering the traffic returns. Take the position of the Government as a land-owner—the increase in the value of the land and land revenue which was fairly attributable to the railways must be very much above the traffic returns of all railways put together. Then again, the railway was a great educator—especially to an ancient and ignorant population. He was told that in the early history of the South Indian system the poor people of the Mofussil used to go out the day before in order to catch a train; they had no idea of trains running at fixed times, and even up to quite lately they would go and sit some hours before the train arrived. The punctuality, and habits of discipline, order, and regularity which the railway system brought with it must induce a desire for similar methods applied to other vocations, and it was largely attributable to that, no doubt, that the agriculture of India had been carried on in a more methodical system, and produced such enormous results. With regard to the rupee question, he looked upon it as simply the working out of a natural law; silver was a commodity like everything else, and was obliged to follow the law of supply and demand. What was the effect on railway finance of this fall in the rupee? Millions of gold had gone out from this country to India in the construction of railways, and there was no difficulty then, because the flow of gold was that way; but when the interest had to be paid on that capital by India, the difficulty was felt, because the interest had to be paid in our own coin in gold, and they had to spend a larger number of rupees in purchasing the requisite amount of gold to pay the interest. But still it was not a loss to them, as they had had the advantage in the first instance, and he protested against the idea that what loss there was should be borne by this country. If there were a loss it ought to be borne by India, because she had had the benefit of the capital on which the return was made, and when they sent goods to India, they got the benefit of the increase in price, which they would not get if they were selling for home consumption.

Sir Charles Bernard, K.C.S.I., said he was not an engineer, but on behalf of the people interested in India he wished to say how much obliged they were to Sir Juland Danvers for this paper. He was probably the most competent man in England for the purpose. He had not only been intimately connected with this question in England, but had also seen the difficulties which had to be overcome in India, and knew what they were. Those difficulties were not quite the same as we had in England, the difficulty of acquiring land, but there were physical difficulties, which no one who had not been in India could appreciate. Within the last month they had heard of difficulties in the West of England, where railways had been stopped in consequence of floods arising from one-half to three inches of rain falling in two or three days; but in India, even in dry parts like Behar and the Nerbudda Valley, they sometimes had from 18 to 25 inches within 24 hours. That was the sort of difficulty engineers out there had to contend with, and, in the first instance, they frequently gave too little waterway. They had continually to increase the waterway, and provide for carrying off the enormous rainfall. They had not to climb mountains, except in Darjeeling and the Bolan Pass, but still all the principal railways did go up to greater heights than any in England ever attained. The railways in India had immensely increased the trade, and had also been great educators of the people in a manner which even their originators did not anticipate. One of the greatest difficulties in India was caste prejudice. The people were very economical, and as third-class travelling was only about a farthing a mile, you now-a-days saw a Brahmin, who a generation ago would never have gone within yards of a low-caste fellow subject, now sitting on a third-class railway bench by his side, and travelling as happily as possible. The railways, therefore, had helped to break down some of the most troublesome and inconvenient of caste prejudices. Before the time of

railways—when the English peace came—agriculture extended, and more land was brought under cultivation. In good years there was a local glut of corn, and in land-locked provinces the produce could not get away, prices were depressed, and the agriculturist suffered very much. On the other hand, in a year of drought, when little produce was to be had, food could not come in from the outside, and the people starved. Now every single surplus pound of wheat was carried away to Europe, where it was wanted, and the people were encouraged to extend their cultivation, whilst in years of drought, when there was no food in a land-locked area, it was brought in from other provinces which had a surplus, and, therefore, both in getting rid of the surplus in good years and by obtaining food in bad years, the agricultural population benefited. With regard to the military considerations, troops could now be concentrated and travelled at less than one-tenth the cost and time formerly required. As everyone agreed, they wanted more railways, and if they did so much good, people naturally asked why did not the Government give more railways. Mr. Kimber had pointed to the contrast between India and America, where ten times more miles of railway were opened yearly than in India; but a great many of the roads in America went bankrupt, some more than once, and they could not afford to have bankrupt roads in India, and were, therefore, obliged to be a little more careful in extending railways. The Government had spent altogether something like £40,000,000 sterling in thirty years, over and above the railway earnings, to keep the railways going, but the consequent advantage to the country was infinitely greater. What the railways did in the way of carrying people and goods was tantamount to putting into the pocket of the Indian producer quite £40,000,000 sterling in one year, and if a debtor and creditor account was to be made out, the good must be put against the bad. But the Government could not go on indefinitely guaranteeing railways. In the present year the treasury were out of pocket nearly 2,000,000 of tens of rupees on the existing railway systems, but still we did not despair of seeing the system much extended in the next generation; and he hoped that capital would be subscribed for Indian railways without guarantee. His idea was that a good company, that would make a considerable railway extension anywhere in India, might get from the Government a corresponding length of open, paying line made over to them. The improvement of trade, however, was not entirely due to railways; the tea industry sprang up in the country with water communication. Something had been said about navigable canals, and he would submit that, so far as he knew, there was not a single canal made as a means of communication only that even paid its up-keep, and he did not know of more than one that did that. The rivers and canals that came to Calcutta were natural rivers which had been improved by engineers, but the canals which had been made as means of communication did not pay; they carried little goods compared with a single line railway. Fifteen years ago, when there was a question of making communication with the land-locked province of Orissa, the zemindars and the people interested said, whatever you do, give us a railway and not a canal. The Government did not take their advice, and made a canal instead of a railway; but the canal did not do the work expected, nor one-fourth of the work which a railway would. Amongst the blessings which India had received from Great Britain, the first was the great blessing of internal peace which it had enjoyed for 40 years, and next to that the railways had been the greatest improvement the country had seen.

Sir JULAND DANVERS, in reply, said there had been an almost unanimous expression of opinion as to the value of the railways, and he agreed with every word that had been said in that direction. No one could appreciate more than he did the great necessity for further efforts being made to carry out more lines, and nobody had a higher sense of the benefit which would be conferred on India by their extension. He hoped to see this accomplished by greater development of private enterprise. It was a tree of rather slow growth, but when it once got root, he trusted it would go on and flourish.

The CHAIRMAN then proposed a vote of thanks to Sir Juland Danvers. The paper contained a remarkable record of progress in the past, which it was very pleasing to look back upon. A good many present remembered, as he did, the old days of travelling, when the maximum of luxury was $2\frac{1}{2}$ miles an hour in a bullock-carriage. Sir Juland Danvers said they now travelled at the rate of 40 or 60 miles an hour, but that rate was entered upon with some fear and trembling. He remembered when he took Lord Dalhousie down his first and only railroad in India for sixty miles into Madras. Before he got on to the engine, and before Lord Dalhousie got into his carriage, he said to him:—"None of your fancy speeds; just take me quietly down." So that he evidently was not quite sure whether they ought to travel at a high speed. Mr. Kimber had alluded to the difference between the length of railways in the United States and in India, but it must be borne in mind that the rate of pay of labourers in India was about one-twenty-fourth of what it was in the States, and where labour was very cheap people were not in so great a hurry to provide substitutes for it as where it was dear. Many allusions had been made to the great advantage which railways were to the people of India, but the last speaker had referred to a greater advantage still, that derived from peaceful government. It was very much the habit to speak of India as having been acquired by the sword and kept by the sword, and

to some extent that was true; but British tenure depended more upon its justice. Some people were accustomed to speak as if the rulers of India were a hard and tyrannical set, and he had something of that feeling before going to India, but he came to a very different idea when he had been there some time, and the people themselves had a very different idea. When he was laying out the Madras Railway near Madras he remembered carrying the survey through some gardens belonging to a village, and as they were acting perhaps in rather an unceremonious way, the villagers came crowding round, and one man rather bigger and finer than the rest came up to ask what they were doing. He wanted to know by what authority they were damaging the people's property, when his reply was that whatever damage was done would be assessed by the collector and paid; upon which the native answered that he was perfectly satisfied so long as it was left to the English magistrate to decide, "for if they were not so just a people how could they govern the whole earth." That was his Oriental way of expressing his estimate of the British Government, and it was a just estimate as regarded its management of India.

The vote of thanks was carried unanimously.

Mr. Hyde Clarke writes:—I wish to write now what I did not say at the meeting. There were certain points in the paper of Sir Juland Danvers which attracted general attention, because they were on the surface. He has handled the subject so long and so ably, that we are apt to think he is always proceeding on the old lines, whereas his power of observation has grown with the growth of railways, and with the progress of his own knowledge. The illustrations of bridges and great works which accompanied his discourse made a great impression on his audience, but their effect will not be existent in our printed *Journal*. Nevertheless, there was a great lesson in these illustrations, because the works they represent are, in the eyes of scores of millions, the visible manifestations of the power of our Government and of the ruling English race. While seditious newspapers are allowed to do their utmost to calumniate our character and weaken our influence, these works make the deepest impressions on the native mind, and recall the great social and economical advantages our railways have conferred upon them. The Indian Fenians willingly dwell on the allegation that the railways are paid for out of taxes wrung from the oppressed people. The timidity of the Government in neglecting to promote the adequate extension of railways gives cover to the agitators. The other side of the matter, that with which Sir Juland Danvers has dealt, is neglected. That is, the vast pecuniary benefits conferred on the taxpayers of India, on man, woman, and child, by railway transit. The capital for the construction of these railways has been transmitted from England to India, and India has yearly sent a portion of interest. In reality India has been enabled to contribute to this interest by the increased prosperity consequent on the railways. It is, nevertheless, made a grievance that the amount to be remitted is now increased by the alteration in the rate of exchange. It is, however, left out of sight that for many years India obtained capital in this market at the low rate of 4 per cent., while our colonies and foreign countries were paying for railway loans 6 per cent. and more. Australia, however, is now paying 3½ per cent. These fluctuations of interest will take place, and it does not follow that India will, in the long run, pay an excessive rate. Whenever the Government, as it has been counselled, takes measures for placing the railway stocks in the local markets, they will be absorbed by the natives, as they have been absorbed in so many foreign countries for which we introduced railways and supplied the capital. There is a want of broad views with regard to the railway question in India, and the comparison between railway extension in India and elsewhere was inadequately discussed in our section. Putting aside the misconceptions about the United States, the facts as to extension in Australia, Canada, and South Africa are conclusive against the Indian administrations. Sir George Bruce touched on one matter which, when fairly considered, opened up the whole subject of railway extension. He said the rate of wages was lower in India than in the United States, and therefore the people in India could not pay such high fares. This is the truth, and goes to the root of the matter. Why, however, are prices lower in India than in Europe, and why should they be so? The fact is, when we began the development of India, there was a casual and exceptional scale of prices that had existed for ages, and such as was found in Japan. The new railways acted on these prices, and a large advance took place throughout India, to its great benefit; and had the Government attended to the currency, the prices would have continued to rise, as I have repeatedly pointed out. While the Government delayed, a great economical revolution, beginning in this country, spread throughout the world. The progress of invention displaced iron, and created cheap steel, for railways, engines, and steamships. The production of wheat, maize, sugar, and coffee, was stimulated, by the consequent lower rates of transport, and the price of these commodities necessarily fell. This would have affected India, as it affected Brazil, but, contemporaneously, India was specially touched by an enormous production of silver, and the depreciation of its chief element of currency. Such are some of the real conditions of a problem with which railway extension in India is immediately connected, and for which it will be the chief remedial agent. This has been dealt with in the Legislative Council in the same spirit by Mr. Steel. Already India has largely benefited by its connection with England, and the resources it thence obtains, for its progress and development. Sir Juland shows that it has been

making durable railways at a reduced rate, with cheap steel, while its produce is taken to market by improved marine transport.

SEVENTEENTH ORDINARY MEETING.

Wednesday, April 3, 1889; COLONEL A. C. HAMILTON, R.E., Member of the Council, in the chair.

The following candidates were proposed for election as members of the Society:—

Dent, John, 8, Fitzroy-square, W.
Edmonds, Richard, Royal Arsenal, Woolwich.
Miller, Robert, 41, Albert-hall-mansions, Kensington-gore, S.W.
Schlich, W., Ph.D., Indian Engineering College, Cooper's-hill, Staines.
Sullivan, William Henry, 69 and 70, Shoreditch, E.
Thomas, William Frederick, Manor-house, Southall, Middlesex.

The following candidates were balloted for and duly elected members of the Society:—

Arnold, Thomas, 19, John-street, Llanelly, South Wales.
Childe, Henry Slade, Wakefield.
Horridge, J. M., care of Messrs. Allen & Co., Caxton-house, Palmerston-square, E.C.
Law, Commander Edward Downes, R.N., 65, George-street, Portman-square, W.
McDougall, James T., Dunolly, Blackheath, S.E.
Rouse, Thomas, 140, Leadenhall-street, E.C.
Syms, William, 58, High-street, Rochester.
Thomas, John James, Ynyshir, Pontypridd.

The paper read was—

FRUIT CULTURE FOR PROFIT IN THE OPEN AIR IN ENGLAND.

By WILLIAM PAUL, F.L.S.

The question of fruit culture in the open air in England is at the present time engrossing a large share of public attention, and, in my opinion, not more than the importance of the subject deserves. Anything that will add to the income derivable from the cultivation of the land by the employment of manual labour, and at the same time add to the supply of wholesome and nutritious food, should receive the amplest and most direct encouragement. Our gardening papers have been fully alive to this fact, and have ably discussed the question. But the matter has not been allowed to rest there. We have had fruit conferences, fruit leaflets, a controversy in the *Times*, and articles on the subject in the *National Review* and the *Nineteenth Century*.

Now, it may probably be a matter of surprise to some that this simple question should have given rise to such a diversity of opinion as to leave the outcome a matter of perplexity and doubt. To those who know, the issue is clear enough, but to those who do not know, the subject must, I think, appear to be left in a hopeless tangle. The task I have allotted myself to-night is the disentanglement of this disorderly skein, and the attempt to lay the threads of it before the public in close straight lines, so that the beginning, the middle, and the end of it may be distinctly seen. Much that has been said and written on this subject has about it the clear ring of truth, but statements have also been made which, if accepted and acted on, will surely lead to disappointment, vexation, and a wasteful expenditure of money. To be told on the one side, that "the salvation of England depends on the future of its fruit culture"—to be advised to break up rich meadows, already giving a good return to owners and occupiers, to form them into orchards, even in questionable situations; and, on the other side, that England cannot compete with foreigners in the open market on account of climate, facilities of transport, and unlimited competition, seem to me to be extreme views which will not bear the test of sober investigation.

For convenience in dealing with them, I will for the moment call these extreme and opposing views optimistic and pessimistic. The optimist is influenced in his opinions by the fruitful orchards he meets with occasionally; the pessimist, by the unfruitful ones which unfortunately abound; neither of them taking sufficient pains to investigate the causes of these different aspects. The "optimists" seem to think that fruit trees may be planted with advantage almost indiscriminately throughout the country; the "pessimists" seem to think that it is of no use for England to try to compete in the English market with foreign countries. The "optimists," although skilful dialecticians, seem to me to possess but a limited knowledge of the subject, so limited as not to know how much remains beyond their ken which, if known, would, I feel sure, considerably modify their opinions. And further, their knowledge seems to be derived more from books than from the safer sources of observation and experience. They perhaps read the gardening papers, and even write for them occasionally, become members of some

horticultural society, and on the faith of this announce themselves as experts when they are only novices. It is true they offer some facts which have, at least in part, been derived from the writings of experienced cultivators; but these facts are so skilfully incorporated with delusive statements, that their teaching is both misleading and mischievous. Judging from the extraordinary gains which they hold out as probable in the future, they do not seem to know that there are already as keen, industrious, and clever men engaged in fruit-growing as in any other business in this country, and although such make good profits, they do not make large fortunes. On the other hand, the pessimists, discouraged by the variation of climate, facilities of foreign transport, and what they consider unlimited competition, and the frequent disappointments arising from various causes—some of which they might have foreseen and controlled—throw up the game in despair. Unfortunately, the abuse of our climate is often favourably received by Englishmen; but for some sorts of fruit it is not, in my judgment, so bad as it seems. It is less favourable than some in certain points, but more favourable in others. Then foreign transport is costly, and competition in good fruit is by no means unlimited. With good cultivation there is no fear of over-production.

I have read not perhaps quite all but the greater part of the recent writings and utterances on this subject, and a great deal on the fruit culture of the past, but I do not depend on that solely for the statements I shall put before you, but to extensive reading combined with more than forty years' experience in the study and cultivation of fruit trees in this country. I may perhaps be excused for saying that, when 16 years old, I had charge of an orchard belonging to my father. That orchard was partly experimental—planted with all the best kinds, to prove which sorts were most suitable for the district, and the best flavoured—and partly a market orchard, consisting of sorts already proved. Although my allotted duties were simply to note the bearing qualities of the different sorts, and overlook the packing for market, my boyish activities were not bounded by these duties. There was not an apple or a pear, a cherry or a plum, a gooseberry or a strawberry, that I did not test the flavour of, over and over again, and note my own judgment of, for future use. There were many visitors to that orchard, and I could conduct the epicure to the sorts with richest flavour as well as the growers for market to the most abundant bearers. From that period to the present time I have always had in hand quantities of fruit trees, part of the produce of which has been sent to the market. I have planted scores and visited hundreds of orchards, and lived to see some of the former arrive at a productive and profitable state.

With these preliminary remarks, I will proceed to consider the subject under the following heads:—(1) Climate and situation; (2) Soils; (3) Sorts; (4) Cultivation; (5) Gathering, Storing, and Marketing; (6) Holdings; (7) Statistics.

Climate and Situation.—Above all things should be avoided a climate in which spring frosts are more than ordinarily frequent or severe. A mild, equable climate, fairly dry, free from sudden changes of temperature, and storms of wind and rain, should be taken in preference. I do not believe in planting apples, pears, cherries, and plums in the bottom of valleys. This is often done on account of the quality of the soil. But it is of little benefit to the grower to realise a good growth, the natural results of a good soil, and abundant flowering, if his crop is destroyed in the flowering state by the spring frosts. Over the last few years there has been a wonderful show of blossom on the fruit trees in the valley of the Lea, but little fruit has followed, owing to the destruction of the embryo by the severity of the spring frosts in this low situation. This is the one point in climate that would seem to render such situation unsuitable for fruit culture for profit, as it can be but partially amended by shelter or any other means. It seems to me that many important points desirable to secure success, which are well known to those who are thoroughly versed in these matters, have not yet taken hold of the general mind, and they cannot be too often repeated till they do this. Only a few years ago, I was surprised to meet with an orchard, newly planted, at the bottom of a moist valley, the climate of which in spring was trying in the extreme for early buds and blossoms. The sorts, too, were injudiciously chosen. Nevertheless, the planter persevered with their culture, until he found that for three or four years in succession his trees produced plenty of blossom but little or no fruit. He then destroyed them, and cropped the ground with vegetables. But what a waste of time and money, and what a source of vexation and disappointment!

I believe in planting fruit trees on slopes or uplands, where the spring frosts are less destructive; but even there, distant shelter should be provided, if not already existing. If cheap, quick-growing trees are planted for shelter, within a few yards of the boundaries of the plantations, when the young fruit trees are planted, the former will afford the necessary shelter by the time the fruit trees come into bearing. I would emphasize to the utmost of my power the necessity of a favourable climate and shelter. On a farm of 200 acres there may be a difference of climate that would render fruit culture profitable or unprofitable, according to the position in which the trees are planted.

In the valley of the Lea, I find that in some years the crop is mainly or wholly on the bottom, and in others on the top of the trees. This I attribute to the spring frosts being more severe in the one case near the ground, and in the other, at a greater elevation during the period of flowering. Or it may sometimes be that the heavy cropping of one part of the tree is the cause of a thin crop on the same part the succeeding year.

2. *Soils.*—A light or medium loam, of good depth and well drained, is generally accepted as the most favourable for the production of an abundance of good fruit. It matters not if it be poor, provided manure can be obtained at an easy distance, or at a cheap rate. A bad soil in a good climate often yields the grower more profitable results than a good soil in a bad climate. A wet soil is always a bad soil. Thorough and deep drainage is necessary when dealing with wet land about to be planted with fruit trees, and this draining improves the climate as well as the soil.

Chalk or gravel would seem to be a better subsoil than clay, as the latter, especially if wet, favours the development of canker. As to soils for the different fruits, I would prefer for apples a medium loam; for plums, pears, and cherries, a light, warm loam; for strawberries, a light, rich loam, cool and moist, with ready access to water; for raspberries, a deep, light loam, also cool and moist; for gooseberries and currants, a deep, strong loam. But I would not convey the impression that these soils are necessary; in well-drained soils cultivation may be safely extended even to strong or clayey loams.

3. *Selection of Sorts.*—In this part of the business there is perhaps no guide so safe as that of actual experience. Sorts that are known to grow well and bear well in any particular district may, provided the produce sells well, be safely planted there. But this experience is always limited. Valuable guides in the selection of sorts are also to be found in the period of flowering, and the frost-resisting powers of the blossoms.

As regards the period of flowering, some sorts flower early, others late. A difference of three or four days often makes the difference of a crop or no crop, as in those three or four days a frost happens that destroys the embryo of the early or expanded blossoms which leaves the unfolded buds unscathed; and this frost may not occur again in the same season. Then as to the frost-resisting power of the blossoms. This is not the same in all cases; some varieties appear naturally less susceptible of frost than others. Again, in some I have observed that the embryo is better protected by the size, form, and substance of the petals which surround it. In some cases the petals, when unfolding, fall into a horizontal position, leaving the embryo fully exposed; in others they remain incurved, offering material protection. Then the substance of the petals differs considerably, practically almost to the extent of the difference in our own clothing between a summer and a winter coat.

It has often been a matter of surprise to me that these important facts have not commanded more attention from our horticulturists. Here statistics would be of immense value to the cultivator, and those who have the leisure and inclination to provide them would be rendering a national service in doing so.

Again, in selecting sorts, we must not overlook the fact that the same sorts of fruits do not flourish equally well in all soils and situations. This, I think, is more a question of climate than of soil, and should be dealt with from that point of view. Once more, the season at which the fruit becomes marketable is an important point to the vendor. A day often makes a great difference in the price of strawberries, and apples should be early or late, with the exception of such favourite sorts as Blenheim Orange, and Cox's Orange Pippin, to avoid clashing with the excess of foreign importations. In my judgment, the best foreign apples do not equal good English fruit in quality, but they often look more tempting, and answer the same purposes, especially for cooking.

Of large fruits grown for profit, apples would seem to stand first, plums next, then pears, then cherries; of small fruits, strawberries, raspberries, gooseberries, and currants are the most important. Filberts may also be planted to give a profitable crop in odd sheltered

spots where other fruits would not grow well. But these different fruits do not all require precisely the same climate and soil. The apple is, perhaps, the least particular in these respects, some varieties of which will thrive and produce large crops of good fruit in almost any well-drained soil, when grafted or budded on the crab or apple stock; the paradise stock, according to my experience, is not so good as the preceding for field culture. I admit that apples grown on the paradise stock, and pears grown on the quince stock will, if highly cultivated produce the finest fruit, and are often the most desirable for gardens; but in orchards would this high cultivation pay? The grower for profit wants quantity as well as quality, which apple and pear trees on these stocks do not generally give.

There are twenty-four sorts of apples which I should plant in preference to others in my own county (Hertfordshire), having an eye to the disposal of the crop as well as to its production; they are, Blenheim Orange, Cox's Orange Pippin, Cox's Pomona, Devonshire Quarrenden, Ecklinville Seedling, Duchess of Oldenburgh, Irish Peach, Keswick Codlin, King of the Pippins, Lord Suffield, Small's Admirable, Stirling Castle, Sturmer Pippin, Warner's King, Wellington, New Hawthornden, Cellini, Dutch Mignon, Beauty of Kent, Lane's Prince Albert, Northern Greening, Worcester Pearmain, Early Julien, and Golden Spire.

I can speak favourably of the Ecklinville Seedling apple from experiments made both in Herts and Sussex. I planted in Sussex, four years ago, 200 dwarf Ecklinville apples; the soil, a quarter of an acre, was good, and had been subsoiled 18 inches deep two or three years previously. They grew well, the third year they produced 5 bushels, the fourth year 17 bushels, which sold on the ground at 5s. per bushel. They were planted about 6 ft. by 9 ft., but strong growers might be planted 9 ft. by 9 ft., and small fruits, such as gooseberries and currants, or vegetables, might be grown between the trees for a few years. I estimate the prime cost and expenses of planting and cultivating of the 200 Ecklinville apple trees, on a quarter of an acre of ground, in 1884, as follows:—

	£	s.	d.
Cost of trees, 200, 50s. per 100..	5	0	0
Planting and digging		15	0
Four years' cultivation at 15s. per year	3	0	0
Rent, rates, &c., at 10s. per year	2	0	0
	10	15	0

	£	s.	d.
Brought forward	10	15	0
Returns in 1887 *and* 1888.			
22 bushels of apples sold on the ground at 5s. per bushel......	5	10	0
Leaving a balance against the cultivator of	5	5	0

Next year I expect to get the outlay back, and look to the future for profits.

Now, I do not offer this statement of facts as statistics from which any valuable inferences as to the future can be drawn, but merely to show the probable result of the first four years' cultivation. Of so-called statistics I shall have something to say by-and-bye.

In exposed situations pyramid, bush, or two years untrimmed trees are preferable to standards, because the fruit is not so liable to be blown down; and in large orchards, if it should be decided to keep the surface under grass, and the trees have stems 2½ ft. to 3 ft., sheep could run under them to feed, and thus help the returns.

Plums.—The Early Prolific and the Victoria are two good ones; other desirable sorts are Early Orleans, the Czar, Diamond, Pond's Seedling, Prince Englebert, and Belle de Septembre. Damsons, also of which the Shropshire and Farleigh are well to the front, are usually a profitable crop.

Pears want a better climate, and a warmer, richer, and deeper soil than apples, and are not usually so profitable a crop. They do well as a rule on a subsoil of chalk. Of pears, Aston Town, Eyewood, Hessle, Williams Bon Chretien, Beurré de Capiaumont, Beurre d'Amanlis, Madame Treyve, Marie Louise d'Uccle, Vicar of Winkfield, and Doyenné d'Eté are the most profitable sorts to grow in Hertfordshire; Louise bonne of Jersey where it will grow well, and Marie Louise, where it will bear freely, are also desirable varieties, on account of their superior flavour.

Cherries like a lighter and deeper soil than apples. The May Duke, Bigarreau Napoleon, Kentish, Bigarreau d'Esperen, Black Tartarian, Governor Wood, Frogmore early Bigarreau, and White Heart are good sorts.

Strawberries. — Vicomtesse Hericart de Thury, Sir J. Paxton, Elton Pine, President, Dr. Hogg, James Veitch, Loxford Hall Seedling, Premier, Oscar, and Sir C. Napier are, according to my experience, the most desirable sorts to grow for profit.

Raspberries.—Carter's Prolific, Fastolff, Fillbasket, Yellow Antwerp, Semper Fideles,

Red Antwerp, and Baumforth's seedling are the best.

Currants.—Of currants I should choose Black Naples, Red Dutch, Raby Castle, La Versailles, Cherry, and Lee's Prolific.

Gooseberries. — Whitesmith, Warrington, Crown Bob, Lion's Provider, Roaring Lion, Broom Girl, Dublin, Lancashire Lad, and Companion are good sorts.

In selecting all sorts of fruits it should not be forgotten that, as previously mentioned, some sorts flower later than others, and the blossoms of some sorts are more frost-proof than others, and thus the crop is often saved by late flowering or frost-resisting blossoms. If I were to plant fruit trees extensively for profit, I should look closely to these matters in the selection of sorts. I would also examine all the fruit trees, and talk to all the practical gardeners in the neighbourhood, whom I could persuade to listen to me, to ascertain which sorts produced the best and most certain crops in the district.

4. *Cultivation.*—There is no greater mistake than to suppose that the ordinary and uninstructed farm labourer can plant and manage an orchard properly. You might as well set him to make a coat or a pair of shoes. The results would not be so quickly visible, but they would be as unsatisfactory in the end. It would surely make some of the present writers on this subject blush to find how much wiser their forefathers were on this subject. Hear what Henry Dethicke says, in the "Gardener's Labyrinth," published more than 300 years ago:—"Not sufficient is it to a gardener that he knoweth, or would the furtherance of the garden, without any cost bestowed, which the works and labour of the same require. No. The will, again, of the workman, in doing and bestowing of charges, shall small avail, without he have both art and skill in the same. For that cause it is the chiefest point in every faculty and business, to understand and know what to begin and follow." And this view has been endorsed by every subsequent writer who knows his business, until a very recent period. But now, at the close of this nineteenth century, when everybody writes, it has become fashionable for those who do not know to undertake to instruct the public. Blind leaders of the blind, they substitute bold and reckless assertions for the thoughtful and painstaking deductions from experience, made and recorded by writers of the past.

If I were about to plant fruit trees, I would dig or trench the ground two spits deep. A few light, yielding soils might be efficiently prepared by the subsoil plough, but even in dealing with them, the spade is a better instrument than the plough. Of course, the manuring and working of the soil is, or should be, more costly than in ordinary farm operations, and the cultivation of the trees, by pruning, and keeping free from insects, is necessary, and is also an item of cost in labour which must not be lost sight of.

The practice of "sticking in" a few trees, by which is often meant merely digging a hole large enough and deep enough to admit and cover the roots, in the way one would stick in a post, cannot be too loudly condemned. However good the soil, however careful the after culture, no satisfactory results can follow it. The soil should be well prepared, and the trees carefully planted and cultivated, according to the recognised methods of our most intelligent and experienced horticulturists.

It is impossible, in the brief space of time allotted for the reading of this paper to enter into the minute details of cultivation; I may say, however, that when planting, the top of the roots should not be more than four inches beneath the surface in heavy soils, and six inches in light soils. The roots, too, should not be huddled together in a dense mass, but be spread out, and the soil worked in between them.

All cultivators will, I think, agree with me that an annual manuring and shallow digging is desirable, and that the pruning-knife should be occasionally used; thinning of the fruit may also often be practised with advantage. The trees, if standards, should also be staked to preserve them from injury by the wind. Of course, the digging cannot take place in orchards that are laid down in grass, but while I would not condemn such, they cannot be spoken of as the highest examples of cultivation.

In some estimates of profits lately put forward, it appears to me that these costs, in connection with the cultivation of the trees and soil, have not been sufficiently allowed for. The improvement of races by selection and cross-breeding falls properly under the head of cultivation. Much has been done in this way by our skilled horticulturists during the last few years. Many of the fruits which now take a lead in the market were unknown there a generation ago. The cultivation of new fruits, although often very profitable, is, however, attended with considerable risk, and should be undertaken with due caution. It is

well to try them on a small scale until such time as their nature and qualities are fairly proved.

5. *Gathering, Storing, and Marketing.*—The gathering of fruit is a point of great importance, and requires a nice discriminative judgment on the part of the most experienced cultivator. To make the best of it, it must be ripe enough, but not too ripe. The colour of the skin is a good guide to those who know, though of little use to those who do not know. Then a second test is the readiness with which the fruit yields when gathered, but this again is a matter which requires experience and judgment. Some fruits are gathered and sent to market direct from the tree; others require storing for maturation. For the latter, a fruit room is necessary. A fruit room should be dry and cool. If built with hollow walls and a double roof, one of straw and one of tiles, heating may be dispensed with. No windows are necessary; fruit keeps best in the dark; but there should be shutters for giving air to dry the moisture which exudes through the skin of apples and pears for the first six weeks after they are stored. Fruit can hardly be kept too cool, provided it is not exposed to frost; a temperature of 40° is about the right thing. Stored fruit should be laid in thin layers—single layers if possible—on shelves; if laid in heaps it is subject to what gardeners call "sweating," and the quality becomes deteriorated.

It must not be overlooked that some fruit—pears especially—require a higher temperature than that mentioned above to mature and acquire a full flavour. But this special management is perhaps more the business of the fruiterer than the cultivator.

It must not be lost sight of that the grower's work is only partly done when he gathers and stores his crops. He has to sell them. To this end he may have to sort them, and pack them so that they may sustain no injury in travelling; he must also market them at the right time. All this requires judgment and experience. A crop may often be disposed of to advantage in the neighbourhood where grown, and when this is the case the costs of packing, carriage, and commission are saved. Like other men of business, the grower of fruit for market must be sufficiently intelligent, industrious, and energetic to find the best market for his wares, or he misses the reward of his skill and labour.

6. *Holdings.*—It is often said one should not plant fruit trees for profit except on his own land. But this would unnecessarily limit the number of growers. A long lease, however, is indispensable. According to calculations I have made, but with which I need not trouble you, 30 years is the shortest lease I should advise anyone to plant under, but this, of course, may be qualified in some measure by the rent. If the lease be for a shorter period, I think the tenant should expect from the landlord either a renewal at the same rent as before, or that his trees be taken at a valuation, or some equitable arrangement made for compensation if the lease is not renewed. It may be thought by some that this is asking too much from the owner of the soil, but I do not think it is more than it is his interest to concede. By such concession he may secure a good tenant and a good rent, and there is ample security for his rent in the value of the trees on the soil, which there is not always in the case of farm crops.

I will read a brief extract from a recent number of the *Sussex Advertiser*, in reference to land tenure in Kent:—

"One of the results of the unsatisfactory system of land tenure now prevailing in this country is to be seen at Knockholt, Kent. The lease expires at Michaelmas, and the tenant is not allowed to renew his tenancy, nor can he recover compensation from his landlord for a valuable plantation of 30 acres of raspberries on the farm. Consequently, the extraordinary spectacle may now be seen of a reaping-machine cutting down, and a steam plough following it, rooting up this plantation, which has cost a very large expenditure of time and money to produce. When it is considered that the produce of the plantation in question realised in the present year upwards of £1,690, and that the plantation was vigorous and in full bearing, some idea may be formed of the sacrifice of property involved."

Without offering any opinion on the course here taken by the tenant (as I know nothing of the case beyond what is here stated), I think you will agree with me that such a wasteful destruction as this is to be deplored.

Under this head, it has often struck me that the manner in which the charges on land planted with fruit trees are levied is not equitable, and is calculated to discourage rather than encourage planting for profit. A few words will, I think, make this plain. A man plants fruit trees, not looking for any quantity of fruit for four or five years. During that period he receives nothing, or next to nothing, in the shape of produce, although rent, charges on land, and expenses of cultiva-

tion are going on, and have to be met. Then, when his crop brings him a larger return than ordinary farm produce would bring, there is probably a re-valuation of the holding and the charges on the land are raised! Now, it would seem only fair, if the charges on land are calculated according to the value of the annual crop, the planter of fruit trees should pay nothing the first four years.

7. *Statistics.*—I should not be acting honestly in this matter if I were to withhold my opinion that most of the statistics lately put forward in favour of fruit growing in England are not worth the paper they are written on. They are ample enough on the score of returns, but meagre in the extreme when dealing with expenditure. But I would also distinctly say that I make no charge of wilful misrepresentation against the authors of them. I know from experience how carelessly such statistics are often made up, in answer to inquiries relating to the past, and how eagerly and inconsiderately they are received when they tend to strengthen the preconceived opinions of the inquirer. And beyond this, some men delight in making themselves appear cleverer than their neighbours; and to this end will give forth the results of one profitable year. But as one swallow does not make a summer, by the same rules of argument, one year's crop cannot be taken as an estimate of the future yearly income. A heavy crop of one year is often succeeded by a light one in the next, and to place this estimate on a sound basis, the average of three, four, or five years should be taken. Statistics, to be of any value, should begin at the beginning. An account should be kept on both sides, from the first shilling spent up to the period when the trees give a marketable return. The sum total to this period may be treated as capital sunk. After this, the average of not less than four years should be taken as the probable yearly returns. Or the matter may be looked at in another way. The capital expended may be set down as money borrowed, on which a fixed interest is to be paid till it is returned. An orchard of the larger fruits may be estimated to last in a good condition from thirty to fifty years, according to the soil and management. Fruit trees come into bearing sooner, and die out sooner, when planted on sandy and light soils than on soils of a heavier or stronger nature.

In conclusion, permit me to say that what I have advanced should not discourage the planting of fruit trees. On the contrary, if I have been understood as I wish to be, fruit culture in England may be judiciously extended to a very considerable degree. But it should be guarded and guided by the appropriate selection of climate, soil, sorts, and, above all, a high system of cultivation directed by a knowledge of the business. With regard to the question of supply and demand, I believe that a much larger quantity of English fruit would meet with a ready sale if put before the public in a tempting state. I may also say that I am clearly and decidedly of the opinion that there are thousands upon thousands of acres of land in Great Britain, at present bringing little or no profit to owners or occupiers, which, if planted with fruit trees, might be made to return a good profit to both. Not that I think large fortunes are to be made by the enterprise, but that a fair remuneration will be secured for the outlay of capital, and the application of knowledge, industry, and skill. Fruit-growing as a recreation, or for one's own use, is one of the most fascinating and diverting of occupations, and may be pursued with satisfaction by the uninitiated. But fruit-growing for profit is a different thing. Here, knowledge is wanted. The possession of it, rightly applied, will be attended with success; the absence of it with failure. It is the height of folly to suppose that this, any more than any other business or profession, can be made profitable without preliminary instruction and training.

DISCUSSION.

Mr. JOSEPH CHEAL congratulated Mr. Paul on the practical nature of his paper, most of which he endorsed. One or two points, however, he took some exception to, as, for instance, he understood Mr. Paul to say that he preferred chalk to clay for fruit growing, whereas his own experience was that chalk was not at all suitable for this purpose. Again, he thought he spoke rather too disparagingly of the paradise and quince stocks; it was quite true that they wanted quantity as well as quality, but at the present day they also wanted something which would produce fruit in the shortest possible time, and both the paradise and quince stocks were likely to induce early fruiting. He quite agreed that the reading of a few newspaper articles was not sufficient education for fruit growing, and that many statements which were made must be received with great caution. There was no royal road to success in this matter more than in anything else, and the old saying which had been quoted still held good—if we would gain success in fruit growing, we must put heart and skill into it. Practical knowledge, combined with skill and perseverance,

opened up the only way in which success could be obtained.

Mr. CHARLES TOWNSEND said he had been accustomed to watch very closely the habits and pursuits of the rural population, and his conviction was that they did not at all understand the cultivation of orchards. If this paper could be communicated to the rural population, and they had sufficient education to appreciate it, the results anticipated would very soon be accomplished.

Mr. JOSEPH CARTER said he knew the gentleman referred to in the quotation which had been read, and he imagined that there must be some reason for the destruction of property referred to beyond what appeared.

Major MACKENZIE said he had not studied this particular subject so thoroughly as his friend Mr. Paul, but he quite appreciated what he had said, and felt sure that fruit culture in this country, if properly conducted, would pay. There were several difficulties in the way, however, which had not been alluded to, one being the question of railway transit, and another, that of markets. Between these two factors the cultivators' profit was lost. If they could secure reasonable railway rates, and a good market, fruit-growing, though it would never be a lucrative occupation, would be fairly profitable. Mr. Paul was quite right to repeat the good advice which was given 300 years ago, and he only wished the same advice was given now. He was one of the best-abused men of the present day over what was called the Epping Forest scandal, because the writers were not practical men. He had gone to considerable inconvenience and expense to induce as many practical men as possible to come and investigate the cause of this scandal. It was a long-neglected forest, with hundreds of yards of perfectly sere underwood, which had become such a danger that the year before last no less than 72 fires were reported to him. Last year being a wet season it did not affect them. He mentioned this point because the paper referred specially to the advice given by incompetent newspaper writers.

Mr. GILBERT HIGHTON feared that in the presence of so many experts it was rather presumptuous on his part to say anything, but there was one point these did not seem to have been alluded to, which was, he thought, of some importance, and that was foreign competition. A remarkable instance of that had come recently under his observation, viz., Californian pears, some of which he had eaten; these were finer than any European pears he had ever tasted. Although they fetched a high price in Covent-garden, they were also procurable at a very low price. Perhaps the latter were not then in the very finest condition, though perfectly eatable and of superlative quality. If fruit of that quality could be sent from such an immense distance, where the cost of transit must be enormous compared to anything in this country, did it not forebode a very serious competition with English fruit in the future?

Mr. TOWNSEND thought that hitherto foreign fruits and other products had been imported to the prejudice of the home cultivator, simply in consequence of the favourable rates granted by the railway companies, but under the recent Act of Parliament he considered this would be put a stop to.

Mr. A. TOOVEY asked if Mr. Paul could give any information as to the mode of disposing of fruit. Last year he sent up a cartload of red currants, and all the salesman returned him was something less than one penny per pound, which he need not say was a price which would not pay for cultivation. At the same time none were being sold retail in London under threepence per pound. It was here that the growers had to complain, and at the same time the demand was checked by the large profit which intervened between the producer and the buyer.

The CHAIRMAN congratulated the meeting on the interesting paper, and the discussion to which it had given rise. Mr. Townsend thought we were now coming to a time when there would be no more preferential railway rates, but he feared that was not so. The railway companies had published lists of prices, in obedience to the requirements of the Board of Trade, which, in some cases, were two or three times what they were before, and in addition to that, although they would not give any one a preferential rate, they would give a drawback, which came to much the same thing. Even if railways did their best, they could never compete with water-carriage. Some probably would remember that about two years ago, when there was a very large production of fruit in Kent, two barge loads were sent down the Medway and up the Thames to London, and the owners succeeded in making a profit when they could not do so when sending the fruit by rail. The fruit-growing itself, which was the subject of the paper, might be done in the most scientific and careful manner; the best sorts, the best soil, and the best mode of cultivation might be selected, but, after all, if you could not get it to market, or if when you got it there you did not get a fair price by free competition in the sale of it, and the whole of the profits except about one-tenth were retained by the middleman it was no use. Everything which could be done in the way of encouraging more open markets, to which everything could be sent freely, was of great importance to the whole industry. As to foreign fruits, one speaker had referred to the superior quality of Californian pears; and he thought himself that he had eaten American apples which were better in flavour than anything he had known produced at home. No doubt it was the sun and climate which gave them that flavour, but there were some sorts

he had seen in America different from anything in England, and which he thought had some advanttages. He hoped fruit-growers would follow the example of cattle and sheep breeders, and by selection and crossing obtain the best kinds of fruits of all sorts for our own climate, and above all, sorts which produced early.

Mr. PAUL, in reply, said he did not prefer a chalk subsoil to clay, but only intended to refer to the fact that he had found pears do well on chalk. In speaking disparagingly of the paradise and quince stocks he only referred to market culture; for garden culture he esteemed them very highly. But he should be sorry to have to get a living by cultivating pears on the quince, or apples on the paradise. At the same time Mr. Cheal was a very high authority, a large and successful cultivator, and he could only say that there was room for diversity of opinion. No doubt railway transit was one thing which worked much to the disadvantage of English fruit-growers. If fruit could, as was stated, be sent 500 or 1,000 miles for the same cost as 50 or 60 miles, and sometimes over the same lines, there must be something radically wrong somewhere, and fruit-growers should combine to get the evil remedied. He had never tasted any Californian pears, but he did not doubt that the superior climate of some foreign countries would bring out the flavour of many fruits to a perfection which could not be attained in this country. He had, however, never eaten any foreign fruit which in his judgment was equal to the best English. Some time ago he had a long correspondence with some fruit-growers in Australia, who wished to know whether growing apples and pears there for the English market was likely to pay. His reply was that nobody could answer the question; that they could only find out by experience; and therefore they had better send a consignment to see what it would fetch, and judge for themselves. They did so, more than a year ago, but he never heard the result, which he probably would have done had it been favourable.

Mr. HIGHTON said he understood that the Californian pears he had mentioned were sent over as an experiment; and that the low price obtained in consequence of some of the stock not being in perfect order had probably deterred the senders from repeating the experiment.

Mr. PAUL thought the same thing would probably be the case from other foreign countries. He felt quite sure that if Englishmen would put their shoulders to the wheel they had nothing to fear at present, or for a long time to come, from foreign competition. But it would not do to go on as they had been doing. If you made a tour through the orchards, except in one or two favoured spots, you would find them in the most wretched condition. The farmer's stock would be in the same condition if he treated them in the same way. The orchards would pay for fair treatment, but they did not get it. The farmer did not believe in his orchard, and neglected it and left it to take care of itself; and they knew what the result of that was with any natural object under cultivation—it died out. He had seen scores of orchards suffering from premature decay, and scores of newly planted ones falling into decay when they ought to be in their prime, through want of attention. If you spoke to the proprietors, they shook their heads and said they did not understand it. Before people undertook the cultivation of fruit they should learn how to do it. The dealers always said there was a great deal of waste with fruit, owing to its perishable nature, and there was no doubt that the more perishable fruits were the least safe to deal with on that account.

The CHAIRMAN then proposed a vote of thanks to Mr. Paul, which was carried unanimously.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings at Eight o'clock:—

APRIL 10.—"The Sanitary Functions of County Councils." By SIR DOUGLAS GALTON, K.C.B.

Papers for which no dates have as yet been fixed:—

"Secondary Batteries." By W. H. PREECE, F.R.S.

"The Use of Spirit as an Agent in Prime Movers." By A. F. YARROW.

"Origin and Manufacture of Playing Cards." By GEORGE CLULOW.

"Automatic Selling Machines." By J. G. LORRAIN.

APPLIED ART SECTION.

Tuesday evenings, at Eight o'clock:—

APRIL 9.—"Architecture in Relation to Landscape." By H. H. STATHAM. E. C. ROBINS, F.S.A., will preside.

CANTOR LECTURES.

Courses of Cantor Lectures will be delivered on Monday evenings at Eight o'clock:—

C. V. BOYS, F.R.S., "Instruments for the Measurement of Radiant Heat." Four Lectures.

LECTURE III.—APRIL 8.—Thermo-piles and thermo-elements—Lord Rosse's arrangement—Hutchin's instrument—Professor Forbes' instrument—The advantage of reducing the size of the bars—Details of manipulation in the case of very small bars—The construction of galvanometers to be used with thermo piles and for some other purposes.

LECTURE IV.—APRIL 15.—D'Arsonval's thermo-galvanometer—Boys' radio-micrometer—Application

of the theory of the instrument to find the best proportions—Modification for showing vertical tremors—Spinning thermo-piles—Instruments depending on change of resistance—Langley's *bolometer*—Advantages and disadvantages of different instruments compared.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, APRIL 8 ... SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. C. V. Boys, "Instruments for the Measurement of Radiant Heat." (Lecture III.)

Geographical, University of London, Burlington-gardens, W., 8½ p.m.

British Architects, 9, Conduit-street, W., 8 p.m.

Medical, 11, Chandos-street, W., 8½ p.m.

TUESDAY, APRIL 9 ...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Applied Art Section.) Mr. H. H. Statham, "Architecture in Relation to Landscape."

Royal Institution, Albemarle-street, W., 3 p.m. Dr. G. J. Romanes, "Before and After Darwin." II. "Evolution." (Lecture XII.)

Medical and Chirurgical, 53, Berners-street, Oxford-street, W., 8½ p.m.

Civil Engineers, 25, Great George-street, S.W., 8 p.m. Sir Nathaniel Barnaby, "Armour for Ships."

Sanitary Institute, 74A, Margaret-street, W., 3 p.m. Mr. W. Jago. "Bread." 8 p.m. Mr. J. F. J. Sykes, "Nature of Nuisances, including Nuisances the abatement of which is difficult."

Anthropological, 3, Hanover-square, W., 8½ p.m. 1. Captain E. S. Hastings, "Exhibition of the Skull of Po Tok, a celebrated Burmese Dacoit Leader; and of the Skull of Sze Chuen, a rebel Chinese Mandarin. 2. Mr. Edward Tregear, "The Maories of New Zealand."

Colonial Institute, Whitehall-rooms, Hôtel Métropole, S.W., 8 p.m. Mr. H. F. Moore, "Canadian Lands and their Development."

WEDNESDAY, APRIL 10...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Sir Douglas Galton, "The Sanitary Functions of the County Councils."

Naval Architects (at the HOUSE OF THE SOCIETY OF ARTS), 12 noon. Annual Conference. 1. President's Address 2. Mr. W. H. White, "The Designs for the new First-class Battle Ships."

Botanic, Inner Circle, Regent's-park, N.W., 2 p.m. Spring Exhibition.

Graphic, University College, W.C., 8 p.m.

Microscopical, King's College, W.C., 8 p.m. Mr. G. Massee, "Revision of the *Trichiaceæ*."

Pharmaceutical, 17, Bloomsbury-square, W.C., 8 p.m.

Royal Literary Fund, 10, John-street, Adelphi, W.C., 3 p.m.

Patent Agents, 19, Southampton-buildings, W.C., 7 p.m. 1. Discussion of Mr. Boult's paper. 2. Mr. G. B. Ellis, "Trade Secrets *v.* Patents."

THURSDAY, APRIL 11...Naval Architects (at the HOUSE OF THE SOCIETY OF ARTS), 12 noon. Annual conference continued. 1. Sir Nathaniel Barnaby, "The Protection of Buoyancy and Stability in Ships." 2. Capt. C. C. P. FitzGerald, "The Protection of Merchant Steamers in time of War." 3. Mr. P. Watts, "The Italian Cruiser *Piemonte*." 4. Mr. J. I. Thornycroft, "Water Tube Boilers for War Ships." 7 p.m. 1. Mr. John Scott, "Experiments on Bursting a Boiler made to Admiralty Scantlings." 2. Mr. J. Macfarlane Gray, "The Ether-Pressure Theory of Thermodynamics applied to Steam." 3. Professor V. B. Lewes, "Marine Boiler Incrustations, and their Formation."

Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

Society for the Encouragement of Fine Arts, 9, Conduit-street, W., 8 p.m. Dr. Leitner, "The Influence of Greek Art upon that of India."

Sanitary Institute, 74A, Margaret-street, W., 5 p.m. Mr. Alfred Haviland, "The Bagshot Sands in relation to Health."

Royal Institution, Albemarle-street, W., 3 p.m. Professor J. H. Middleton, "Houses and their Decoration, from the Classical to the Mediæval Period." (Lecture IV.)

Electrical Engineers, 25, Great George-street, S.W., 8 p.m. Mr. John B. Verity, "Underground Conduits and Electrical Conductors."

Mathematical, 22, Albemarle-street, W., 8 p.m.

FRIDAY, APRIL 12...Naval Architects (at the HOUSE OF THE SOCIETY OF ARTS), 12 noon. Annual Conference continued. 1. Mr. B. Tower, "An Apparatus for Providing a Steady Platform for Guns, &c., at Sea." 2. Professor V. B. Lewes, "The Corrosion and Fouling of Steel and Iron Ships." 3. Mr. R. E. Froude, "The Part played in the Operations of Propulsion by Differences in Fluid Pressure." 4. Mr. R. E. Froude, "Remarks on Professor Greenhill's Theory of the Screw Propeller." 7 p.m. 1. Prof. P. Jenkins, "The Connection between the Curve of Stability and the Metacentric Curve or Locus of Pro-Metacentres." 2. Mr. W. W. Rundell, "Compass Adjustment in Iron Ships." 3. Mr. A. F. Hill, "Boat Lowering."

United Service Institute, Whitehall-yard, 3 p.m. Lieut. W. C. Crutchley, "The Unprotected State of British Commerce at Sea."

Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting, 9 p.m. Lord Rayleigh, "Iridescent Crystals."

Astronomical, Burlington-house, W., 8 p.m.

Sanitary Institute, 74A, Margaret-street, W., 3 p.m. Mr. B. Redwood, "Domestic Uses of Petroleum Products." 8 p.m. Mr. A. Wynter Blyth, "Sanitary Law—General Enactment—Public Health Act, 1875—Model Bye-laws."

Quekett Microscopical Club, University College, W.C., 8 p.m.

Clinical, 53, Berners-street, W., 8½ p.m.

New Shakspere, University College, W.C., 8 p.m. Dr. F. J. Furnivall, (1) "A Note on Ophelia's 'virgin crants;'" (2) "The 'Midsummer Night's Dream,' contending 'that the fairies are the primary conception of the piece, and their action the main action,'" by the late Sir Henry Sumner Maine, written in 1848.

Historical, 11, Chandos-street, W., 8½ p.m.

SATURDAY, APRIL 13...Royal Institution, Albemarle-street, W., 3 p.m. Lord Rayleigh, "Experimental Optics." (Lecture VIII.)

Physical, Science Schools, South Kensington, S.W., 3 p.m. 1. Mr. Shelford Bidwell, "A Lecture Experiment, illustrating the Effect of Heat on the Magnetic Susceptibility of Nickel, and an Experiment showing an Effect of Light on Magnetism." 2 Mr. G. M. Whipple, "The Dark Flash seen in some Lightning Photographs." 3. Mr. C. V. Boys, "Quartz as an Insulator." 4. Mr. A. P. Trotter, "A Refraction Goniometer." 5. Professor R. T. Anderson, "Apparatus to Illustrate Crystal Forms."

Botanic, Inner Circle, Regent's park, N.W., 3¾ p.m.

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FRIDAY, APRIL 12, 1889.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CANTOR LECTURES.

Mr. C. V. Boys, F.R.S., delivered the third lecture of his course on "Instruments for the Measurement of Radiant Heat," on Monday evening, 8th inst.

The lectures will be printed in the *Journal* during the summer recess.

Proceedings of the Society.

EIGHTEENTH ORDINARY MEETING.

Wednesday, April 10, 1889; Lord Lingen, K.C.B., in the chair.

The following candidates were proposed for election as members of the Society:—

Corbett, Thomas, 70, Camden-road, N.W.
Dunn, William Haynes, 9, Brownswood-park, Green-lanes, N.
Naylor, Robert Anderton, Cuerden-hall, Thelwall, Warrington.
Ram, Raizda Bhagat, Jallundhur, Panjab, India.
Saraswiti, Swaine Bhaskra Nand, Jodhpore, India.

The following candidates were balloted for and duly elected members of the Society:—

Lockwood, Crosby, 139, Highbury New-park, N., and 7, Stationers'-hall-court, E.C.
Sandell, Frederic David, 181, Queen Victoria-street, E.C.
Schloss, Leopold, 17, Leinster-gardens, Hyde-park, W.

The paper read was—

THE SANITARY FUNCTIONS OF COUNTY COUNCILS.

By Captain Sir Douglas Galton, K.C.B., D.C.L., F.R.S.

In future years it will, I think, be allowed that the greatest revolution which has been effected by one movement in this country has been effected by the creation of County Councils. At present we stand only on the threshold of the change, and its full significance will not be felt probably for some few years.

In the country districts the people have hitherto had no voice in the administration of county affairs. The magistrates who were charged with administering county finance were appointed by the Lord Chancellor from among names recommended by the Lord Lieutenant; whilst the executive administrators of London were elected from among the vestries, and the ratepayer had only a very modified control over the selection of the persons who spent his money. The County Council brings the ratepayer into direct contact with his representative, and gives him the opportunity of bringing forward his wants and aspirations; it thus affords a machinery by which public opinion in a district will obtain form and the power of expression.

When this is fully realised, it is certain that wants affecting the social condition of the population, which have hitherto been vaguely felt, and inconveniences which have been patiently borne, will be discussed and formulated, social questions will assume a prominence which they have not hitherto possessed; and the era of change upon which we are now entering will, by degrees, lead to a vast improvement in the social well-being of the people.

At the root of many of these social questions which are pressing for consideration lies that of the health of the people; and my object to-night is to indicate the direction in which the County Councils will be able to influence the sanitary condition of the country.

Sanitary Functions of Provincial County Councils.

No doubt the powers of a County Council in the provinces, in respect of sanitary administration, are very much smaller than those which have been laid upon the Metropolitan County Council, but even in the provinces, under these limited powers, the County Council may,

if it chooses, exert a very large influence. We possess laws at the present time which might be worked so as to ensure efficient sanitation over the whole country. The Public Health Act of 1875 collates the chief provisions up to that time. The Act termed Brown's Act supplemented that Act by providing for the improvement of the water supply of villages; and notwithstanding the fact that this Act has not yet received full practical application, all medical officers of health will bear testimony to its enormous value in checking zymotic disease. The Food and Drugs Acts have done much towards protecting the poorer classes from the adulteration of food.

The Acts for regulating the condition of the housing of the working-classes have not as yet had a marked influence in country districts, and the Acts for preventing the pollution of rivers may be said to have largely remained in abeyance. But we may be certain that, as public opinion is brought to bear on the question of sanitation, so will those Acts—or, probably, more efficient Acts which will have to be passed—enable us to preserve the purity of our water-supply, and to improve the condition of the dwellings of the poorer classes. In regard to this latter question especially, we congratulate ourselves that the dwellings of the poorer classes have been largely improved during the last half-century; but I venture to predict that, under the influence of the County Councils, the next quarter of a century will show largely improved results; and that, just as people clothed in rags are now seldom seen, so insanitary hovels and wretched habitations will not be permitted.

Causes of Neglect of Sanitation.—At the present time, when the sanitation of a locality falls short of the necessities of the case, it is chiefly because the laws which exist are not adequately administered. It is true that where insanitary conditions largely prevail, the machinery of the Local Government Board may, under certain circumstances, be put in operation to compel their removal. But the Local Government Board is a long way off, and it is too big a machine to be set in motion, except on occasions of great importance.

We may make laws, but those laws will not be enforced unless public opinion co-operates to enforce them; and although amongst the very remarkable changes which have taken place during the last 15 or 20 years, perhaps none is more remarkable than the change of opinion in regard to sanitation; yet apathy, rejudice, ignorance, and selfishness still prevail largely to prevent a due effect being given to the sanitary legislation which exists. It is in these respects that we may anticipate that improvements will take place under the new County Councils.

Sanitary Officers of Unions and Local Boards.—The local machinery which exists for watching over the health of the community consists of the medical officers of health and the inspectors of nuisances, or sanitary inspectors, as they are now often termed.

The post of medical officer of health is of comparatively recent creation; it may be broadly stated that whenever a sanitary authority has carried out improvements and done useful work in the protection of public health, it has been at the instigation of the medical officer of health; and where the authorities have neglected their duties it has been sometimes because the medical officer of health has failed to supply the stimulus that was necessary to provoke them to action; sometimes because his position in regard to the authorities, or to his work, has not been such as to give his advice the weight which it ought to have carried; and sometimes because the persons whose duty it is to enforce the recommendations of the medical officer of health, or of the sanitary inspector, are the owners of the insanitary property. These people value a medical officer of health, or a sanitary inspector, in proportion as he manages to overlook the defects in their own cottages. And yet, whilst the position of the sanitary service in many parts of the country is unsatisfactory, sanitary progress has been very marked in large towns, and in districts which have combined for the appointment of a health officer, where men of the highest ability have been appointed, with adequate salaries, and who give their whole time to their sanitary duties.

Position of Medical Officer of Health.—But many difficulties seem to have been interposed by the Legislature to prevent the medical officer of health from being efficient. He has no security of tenure. His appointment is generally for a period of three or five years; and in many cases medical men who have thus devoted themselves to their sanitary duties, and who for this purpose have given up private practice, have not been re-elected, because members of the authority under whicn they served have, for personal reasons, opposed their re-election.

Then well paid officers are the exception;

the ordinary health officer is often inadequately remunerated, and must depend upon private practice, and for this reason he must be careful not to offend his neighbours.

As a corollary to this question of remuneration, it must be added that the Public Health Act provided that the Local Government Board should prescribe the qualifications to be required from medical officers of health; under the order which the Board issued it was required that they should be registered under the Medical Acts, and be qualified by law to practice both medicine and surgery, but there was no stipulation that the officer selected should possess a knowledge of sanitary science, that is to say, a knowledge of preventive medicine as distinguished from the cure of disease.

It is obviously essential, if the best results are to be obtained, that the health officer should be duly qualified to perform the duties of his office, that he should receive adequate remuneration for his services, and that his tenure of office should depend rather upon the efficient discharge of his duties than upon the caprice of those to whose neglect of duty he is obliged by his position to call attention.

The Royal Sanitary Commission recommended, so long ago as 1871, that in order that the medical officers of health might be able to discharge their duties without fear of personal loss, they should not be removeable from office except with the sanction of the central authority.

Position of Sanitary Inspectors.—The inspector of nuisances, or sanitary inspector, has an equally doubtful tenure of office; there is no security that he shall possess educational and technical fitness for his post, and there are numerous instances where individual inspectors of nuisances who have been appointed are so ignorant of their duties as to be worse than useless. The Sanitary Institute has endeavoured to remedy this state of things by holding examinations and granting certificates; but until the possession of a certificate is made a necessary prelude to an appointment, there can be no security against the selection of inefficient men. The sanitation of the country practically depends upon the sanitary service, which consists of the medical officer of health, assisted by the sanitary inspector; and until this is rendered efficient by adequate remuneration and security of tenure, little real progress can be expected.

Powers of Sanitary Supervision vested in County Councils. — The Local Government Act of 1888 gives the County Council the power of supervising, to a certain extent, the sanitary administration of the country, by requiring the medical officer of health of every district or union to send to the County Council copies of his periodical reports on the health of the district; and if the County Council consider that the provisions of the Public Health Act of 1875 have been neglected, or if they consider that any other matter affecting public health requires to be remedied, they may cause a representation to be made to the Local Government Board on the matter.

The Local Government Act also vests in the County Council the same powers of making bye-laws as the Town Council of a borough possesses under the Municipal Corporation Act of 1875. This power includes, *inter alia*, bye-laws "for the prevention and suppression of nuisances not already preventable in a summary manner by virtue of any Act;" such, for instance, as bone boiling, manure making, and other matters. The county analyst is an officer of the County Council, who thereby will exercise supervision over the Acts regulating the sale of food.

Besides these powers, the County Councils have the power of enforcing the provisions of the Rivers Pollution Act, 1876, in relation to all streams within their jurisdiction. This power is in addition to powers already possessed by existing sanitary authorities.

This is an important responsibility, and one difficult to discharge. Our increasing population tends to continue, if not to increase, the pollution of our rivers.

No doubt some rivers have improved since the Rivers Pollution Act was passed, but many others are as foul as when the Royal Commission reported many years ago. The continuance of the evil is partly due to the fact that the enforcement of the Act is in the hands of authorities who are, perhaps, themselves the greatest offenders against its provisions. This pollution may be classed generally under four heads. First, the pollution from manufactures, concerning which it may be urged that there is often a natural hesitation to interfere with or hamper manufacturers, who already find it difficult to compete successfully with foreign markets; this may, to some extent, cause a disinclination to enforce the purifications of streams so polluted. Secondly, the pollution from mines. Thirdly, the pollution from the direct flow of sewage from large establishments, villages, and towns into streams and rivers. Fourthly, the pollution which arises

from effluents of so-called methods of sewage purification, which have retained much of the putrescible condition which appertained to the sewage.

In the enforcement of the Rivers Pollution Act, any County Council has power to contribute towards the cost of prosecutions under the Act instituted by any other Council or by any urban or rural authority; and, moreover, the County Councils of one or more counties through which any river or tributaries of a river pass may combine to constitute a joint committee, which, under a provisional order of the Local Government Board, could obtain all the powers of a sanitary authority under the Rivers Pollution Act; and the expenses incurred would be paid by the several administrative counties which combined to create the joint committee. This power affords a valuable means of protection for watershed areas.

Functions of Medical Officer of Health to a County Council.—In order to afford the County Council a skilled adviser in these matters, it may appoint a medical officer of health, who may be precluded from holding other appointments or from taking a practice, such medical officer to be a duly qualified practitioner; and after 1892 every person appointed as medical officer to a County Council, or to a district or combination of districts having a population of 50,000 or upwards, will be required to hold a diploma in sanitary science, public health, or State medicine, or else to have been during three consecutive years preceding 1892 a medical officer of health in a district or combination of districts of over 20,000 population. These provisions are a recognition of the facts that the due performance of the duties of a medical officer of health requires an education in the science of preventive, as contradistinguished from curative, medicine, as a preliminary to the proper sanitary administration of a district. The importance of this recognition is not to be measured by the effect on these appointments alone. The influence of such a provision will be far reaching, because it will bring before the educational establishments of the country the necessity of providing education for, and instituting examinations in, sanitary science, and for granting diplomas and certificates, and will thus accelerate the education of the public generally in matters of sanitation.

The medical officer of health appointed by a County Council will not, however, be able to exercise any executive or administrative functions beyond advising the County Council, unless he is appointed to act at the same time as medical officer of a Poor-law Union or of a District Council, which was the body proposed in the Local Government Bill as originally drawn, to take charge of the highways, other than main roads, and sanitation. Consequently, he would only derive his knowledge of the sanitary condition of different parts of the county from the periodical reports of the medical officer of health of the Unions, which have to be sent to the County Council. If the local medical officer of health fails to send a copy of his report to the County Council, they may refuse to pay the contribution to his salary; it may, therefore, be assumed that the medical officers will readily prepare their reports, or furnish sanitary information, in such form as may be desired, so that we may hope that eventually these reports will be rendered upon a uniform system all over the country. The medical officer of the County Council would be the executive adviser of the County Council on questions affecting the pollution of rivers.

This duty of supervision, although limited in this way, may become a very important function. A skilled and independent adviser would examine and epitomise the reports of the local officers; he would consider the facts and figures of one locality in the light of the facts and figures of other localities; and he would arrange those facts and statistics with a view to elucidating the influences which are at work, and are prejudicial to the health of the county as a whole. And a body of skilled county health officers, scattered over the country, and in touch with one another, through the medium of the able, though small, staff of the Medical Department of the Local Government Board, would afford an admirable opportunity for the study of the distribution and peculiarities of many diseases.

Registration of Infectious Diseases.—There is one matter of sanitation in which we are singularly remiss, and that is the arresting of infectious disease at its first appearance.

In tracing out the sanitary history of a community, the statistics of illness from those diseases which are favoured by insanitary conditions are as essential to possess as the statistics of the deaths. Indeed, sanitation can only rest upon a sure basis provided the statistics of sickness from epidemic diseases as well as those of death, and the probable causes of these occurrences, are accurately recorded and intelligently studied.

The registration of sickness would designate the localities where disease is most rife, as well as those where there is less tendency to particular classes of disease and infirmity; it would, moreover, indicate the extent to which epidemics vary in different localities, seasons, and classes of society. But, to obtain this knowledge with accuracy, it would be necessary that all the cases of epidemic disease, as well as of the deaths, should be accurately recorded, collated, and carefully considered, by skilled persons, in their relation to the conditions which prevail in the several localities where they occur; to assist in this the areas of registration should be smaller than they now usually are, and their boundaries should be more carefully adapted to the sanitary condition of the localities.

In addition to this rearrangement of registration areas, it is essential to obtain from the Legislature the enforcement of the compulsory notification and immediate isolation of all cases of infectious disease over the whole country.

The medical officer of a county council would be a convenient focus in each county for the necessary re-arrangement of registration areas, and for the efficient organisation of the service for notification of infectious disease, and for seeing that isolation hospitals were provided when required; but the first thing for the medical officer of the County Council to do is to collate the health statistics of the county, partly with the help of the periodical reports, and other information furnished by the medical officer of health of the Union, or other local authority, and partly with the assistance of the registrars.

Object of the Sanitary Supervision by County Councils.—The advantage of giving the County Council the functions and the opportunity of examining into the way in which the local sanitary authorities perform their duties, is that the County Council is comparatively independent of the influences prevailing in any particular locality. Thus the new legislation enlarges the area of supervision, and yet still keeps it local, and will bring to bear on the local authorities an influence independent of their local surroundings; whilst, at the same time this influence will be sufficiently near at hand to act without delay.

By this means the private influences which now so frequently prevail to stop the removal of sanitary defects will be controlled, whilst, at the same time, that amount of local and individual interest in the question which is essential to a due enforcement of the law is retained.

Thus, through the operation of the County Council, public opinion and public interest will be brought to bear upon the sanitary shortcomings of a district, and an easy opportunity will be afforded for enabling attention to be called periodically and publicly to these shortcomings. This will help to educate public opinion in the importance of these questions. It will bring into discussion the various methods by which sanitation may be promoted, and this discussion will do far more to advance sanitary science than any edicts for improvements which might be issued from a central board or public department; and whilst under the powers which have been conferred on the County Councils we may anticipate a great advance in sanitation, we may confidently look forward to a vast increase in general education in sanitary knowledge, as the outcome of the proper enforcement of the powers of the County Council, and thereby to the creation of a demand for further progress.

In a thickly peopled country like England, it is necessary that, even in the country districts, the proceedings of the population should be regulated by bye-laws not much less stringent than those necessary for an urban community; and I trust that the spread of sanitary knowledge will call for the regulation of the construction of dwellings, drainage of the soil, and other subsidiary matters affecting public health in rural districts.

The first condition of progress is unity of administration, and Mr. Ritchie's scheme of local government is now waiting for the further scheme, which, by the simplification of areas, and the unification of authorities and rates, is to complete the edifice which he commenced last year. The County Councils in the provinces have thus, so far as sanitation is concerned, chiefly permissive duties, which will produce beneficial results in proportion to the zeal with which they are taken up.

The London County Council.

In the metropolis, on the other hand, the County Council has more distinct powers and more definite duties. The Metropolitan Board of Works has been abolished; the separation of the jurisdiction exercised by the Metropolitan Board of Works from that of the City of London has been to a great extent removed, and ere long will, it is believed, disappear entirely; the whole of the metropolitan area

may thus be said to have become a separate county, and its five million inhabitants have a representative governing body elected directly by the ratepayers.

The London County Council starts with a clear field before it. It is to be hoped that it will profit by the experience gained by its predecessor, the Metropolitan Board of Works, and fill up some of the sanitary gaps which that body has left behind it.

Want of Unity of Sanitary Jurisdiction.—But the Metropolis, even with its new County Council, is under a disadvantage as regards sanitation compared with other towns. For even in its present form the County Council does not posses complete unity of jurisdiction. There is no one authority having sanitary control over the Metropolitan area. The infectious hospitals and the asylums are under the independent control of the Metropolitan Asylums Board.

There is no single jurisdiction over the drainage. The County Council is in charge of the main drainage; but if the sanitation of a town is to be efficiently administered, the same authority should have a supervision and control over the sewage from the sink or w.c. in the house till it is finally disposed of at the outfall. In London the system of house drainage and sewers, other than main sewers, have remained generally in the hands of the Vestries, notwithstanding the powers which the Metropolis Local Management Act gave to the Vestries to transfer their powers as to sewage and drainage to the Metropolitan Board of Works.

Principal Sanitary Functions of the London County Council. — The London County Council takes over the duties with which the Metropolitan Board of Works was entrusted, in respect of the removal of sewage from the metropolitan area, as well as the duty of regulating the laying out of streets, and the construction of buildings; and it is empowered to assume other functions, which were until now partly in the hands of the Metropolitan Board of Works and partly in the hands of the Vestries, relating to the housing of the working classes. A retrospect of the action of the Metropolitan Board of Works in furthering the sanitation of the metropolis shows that that Board has left much still to be effected.

Building Acts.—The Board was created in 1855, and a Building Act was passed in the same year. The only provisions which that Act may be said to contain bearing upon sanitation, exclusive of protection from fire, were the insufficient regulations that "every building used, or intended to be used, as a dwelling-house, unless all the rooms can be lighted and ventilated from a street or alley adjoining, shall have, in the rear, or on the side thereof, an open space exclusively belonging thereto, to the extent at least of 100 square feet." Thus the space to be compulsorily reserved at the back of a building of 30 ft. frontage would have been about 3 ft. wide, or for a building of 40 ft. frontage of about 2 ft. 6 in. wide. And it was not until 1878 that the Metropolitan Board of Works passed a new Building Act. In that Act the words, "For the purposes of health," are first introduced, and used in connection with regulations as to "the mode in which, and the materials with which, foundations and sites shall be made, formed, excavated, filled up, prepared, and completed for securing stability, the prevention of fires, and for purposes of health."

By this Act the Metropolitan Board of Works were also empowered to regulate "the description and quality of the substances of which walls are authorised to be constructed for securing stability, the prevention of fires, and for purposes of health."

In 1882, the Metropolitan Board of Works passed a further very meagre provision in the direction of health, requiring that an open space "shall be reserved at the rear of every building, free from any erection thereon above the level of the ceiling of the ground floor storey, and extending throughout the entire width of the building." Such space would be from 10 ft. to 15 ft. wide.

When we consider the great dangers to health which arise from our metropolitan population, which is crowded into an area larger than has ever been previously built over in the history of the world; and when we consider the enormous importance of doing everything to allow of the circulation of fresh air around and through our houses, we may well feel surprise that so little attention has been paid to the requirements of health in the building laws of the metropolis. The most enlightened municipalities of our provincial towns have taken up the question of healthy construction with much more energy than the Metropolitan Board of Works.

When we look abroad, we find that the authorities of New York (where the "*laissez faire*" system had been inherited from us) recognised many years ago the dangers which they were incurring by negligence in this respect, and adopted an efficient system of

control over the design and construction of new houses, especially tenement houses.

Thus a great duty has been neglected by the Metropolitan Board of Works. I mean the duty of devising and passing a Building Act to enforce the sanitary design and distribution of buildings; such an Act should have enforced the provision of adequate air spaces and light in the front and backs of our houses, especially in relation to the great height to which buildings are now carried; it should require that air and light should penetrate to every part of the house; and it should so regulate the means of warming our houses and cooking our food as to free the atmosphere, at least partially, from the smoke which assists in creating our fogs, which increases their permanence, and which deprives us in London of at least two-thirds of our daylight in winter.

These are sanitary questions connected with building Acts which lie ready to the hand of the London County Council to take up, and thereby earn the gratitude of the community.

Housing of the Poorer Classes.—In connection with this question, we may usefully consider the powers of the London County Council in regard to the housing of the working classes. Briefly stated, these powers may be classed under the Acts passed by Lord Shaftesbury, the Acts passed by Mr. Torrens, and the Artizans' and Labourers' Dwellings Improvement Acts, passed between 1875 and 1888, of which the earlier were introduced by Lord Cross, and are generally known as Cross's Acts.*

Lord Shaftesbury's Acts provide for the establishment of well-ordered lodging-houses for the labouring classes, and the expression lodging-houses includes "separate houses or cottages, whether containing one or several tenements." They may be adopted by the London County Council, with the approval of one of Her Majesty's Principal Secretaries of State.

The Council may, for the purposes of the Acts—(1) Appropriate any lands vested in it; (2) Purchase or rent any lands; (3) Purchase or rent lodging-houses, either existing or intended to be built; (4) Sell or dispose of any lands vested in it for the purposes of the Acts, applying the proceeds, or a part thereof, towards the purchase of other lands better adapted for these purposes; (5) Exchange any lands vested in it for the purposes of the Acts for other lands better adapted for these purposes. The lands so purchased, leased, sold, or exchanged may be situate either within or or without the metropolis; and, with the approval of one of her Majesty's principal Secretaries of State, may be acquired by compulsory purchase, as under the Lands Clauses Consolidation Act, 1845. The Council would have the entire management, control, and regulation of, and may make reasonable charges for tenancy of the lodging-houses; and it may make and enforce bye-laws for their management and use, and especially for securing the due separation at night of men and boys above eight years old from women and girls; and for preventing damage, disturbance, and indecent and offensive language and nuisances; and may fix penalties for breach of such bye-laws. If the Council, after an experience of not less than seven years, find any houses too expensive or unnecessary to be kept up, it may sell them.

* Mr. W. Chance has published a very valuable compendium of these Acts, for the use of the County Council.

The Torrens's Act of 1868 provided for the compulsory repair or demolition of houses unfit for human habitation. In consequence of there being no provision for rebuilding in the Act it became unworkable, because the only effect of demolition without the power to rebuild was to leave waste spots scattered about the Metropolis, and it was amended in 1879 by an Act introducing a power of rebuilding, and which authorised the Metropolitan Board of Works to put it into force.

As they now stand, Torrens's Acts can be utilised in the Metropolis where there are:—(1) Premises so dangerous to health as to be unfit for human habitation. (2) Buildings so obstructive as to render other buildings unfit for human habitation, or to prevent them from being improved. (3) Houses decided by the London County Council to be best dealt with under the Acts. (4) Areas and houses decided by a Secretary of State to be best dealt with under the Acts.

Torrens's Acts are useful in dealing with small areas. Cross's Acts, on the other hand, are intended to deal with large areas only. The London County Council is the local authority in the Metropolis (excluding for the present the City, over which the Commissioners of Sewers still hold sway) for enforcing these Acts.

The Acts apply (1) to areas found to be occupied by houses and streets injurious to the health, either of the occupants of the houses, or of the neighbourhood generally; and (2) to areas which cannot well be dealt with under Torrens's Acts, and which a

Secretary of State decides should be dealt with under Cross's Acts. Their provisions, shortly stated, are to the following effect:—If a medical officer of health finds any area occupied by houses and streets in an unhealthy state (whether it has come under his own observation primarily, or been brought to his notice by two justices, or by twelve or more ratepayers), and he considers that the only mode of remedying the evils is by a re-arrangement and reconstruction of the streets and houses, it is his duty to make an official representation to that effect to the Council.

Upon receiving any official representation, the Council must proceed to consider it, and if it resolves that the area is an unhealthy one, may prepare a scheme for its improvement. If it resolves to the contrary, or neglects to consider the representation entirely, it must explain the reasons for its action to a Secretary of State, who has then to direct an inquiry into the matter. It may provide for widening existing approaches to the area, or for rendering it otherwise more open; for proper sanitary arrangements; for the scheme being carried out by the person entitled to the freehold, or with his concurrence, under the superintendence and control of the local body itself, and upon such terms and conditions as may be agreed upon between them; for the housing of the displaced population in suitable dwellings, either by re-housing the whole of them upon or in the vicinity of the area, or, with the consent of a Secretary of State, for re-housing the whole or a part of them at some place where dwellings are already or about to be provided for them, or, with the same consent, for so accommodating at least half of the number displaced by the improvement.

The above summary of the powers possessed by the London Council show that it possesses very important functions — functions which were exercised to some extent under the Metropolitan Board of Works, and which would probably have had a larger operation had there been more outside initiative.

It is essential to the well-being of the rapidly-extending population of London that these functions should be exercised; and to secure this, it is probable that some amendment of the law would be desirable.

For instance, medical officers of health, for the purposes of Cross's Acts, can at present only be appointed by the Council with the assent of a Secretary of State. Inasmuch as under the Local Government Act the Council may appoint medical officers of health (and there are strict regulations as to their qualification), this assent should not now be requisite.

For the enforcement of Torrens's Acts, the County Council should be the local authority in all cases, instead of being the local authority only where vestries and local boards neglect or refuse to enforce the Acts. And it should have power to compel the owner to execute the necessary works where an order has been made by it to put unhealthy premises into a proper condition.

The question of compensation to be paid for insanitary property is one which requires further legislation, for it is manifestly unreasonable that persons who allow their property to fall into an unhealthy condition should be able to claim on prospective value. Nor should they be able to claim upon the income which they may be deriving from letting the property in an insanitary condition, such as overcrowding it. It is also reasonable that the London County Council should have the power to enforce the execution of laws relating to public health, where Vestries or Local Boards have neglected to fulfil their duties in those respects.

Metropolitan Sewage Disposal.—Another important duty which was laid upon the Metropolitan Board of Works by the Act of Parliament which created them, was that of dealing with the London sewage. It cannot be said that this question is left by them in a satisfactory condition.

The Royal Commission on Metropolitan Sewage Discharge reported, in 1884, that the evils resulting from the present system under which sewage is discharged into the Thames by the Metropolitan Board of Works, imperatively demand a prompt remedy. These evils still continue.

It is interesting to trace the history of the metropolitan drainage under the Metropolitan Board of Works.

The Act of 1855, which created the Metropolitan Board of Works, imposed upon them the duty of making such sewers and works as they may think necessary for preventing all or any part of the sewage from passing into the River Thames in or near the metropolis; but it was enacted that the plan for such sewers was to be approved by the Commissioner of Her Majesty's Works before the works were commenced.

In 1858, the Metropolitan Board of Works submitted their scheme to the Government, who appointed a Committee of Referees to advise them thereon. The referees were

myself, Mr. Simpson, and Mr. Blackwell. The referees condemned the plan on the following grounds:—That it did not make sufficient provision for the future increase of sewage in the Metropolitan districts; nor did it provide for the removal of a sufficient amount of storm water during rain to prevent the flooding of low-lying districts; nor to prevent the frequent pollution of the river. They further condemned it on the ground that the proportion of sewage to be raised by mechanical means was far larger than necessary, the sewage from only 27 square miles of the metropolitan area being proposed to be removed by gravitation, the sewage from the remaining 92 square miles being pumped, part of which was pumped twice. They objected that the proposed outfalls at Barking and in Erith Reach were so close to the metropolitan boundary, that they would not effectually prevent the sewage from returning with the tide within the limits of the metropolitan boundary; and that the part of the river selected for the outfall being full of shoals, which cause eddies and slack water, the sewage would be liable to form deposits of mud in these reaches, of the same putrescible character as was then found in the Thames in London.

The referees proposed, as an alternative scheme, to increase largely the area from which the sewage should be removed by gravitation, so as to avoid the cost of unnecessary pumping; that is to say, they proposed that the sewage arising in 81 square miles of the metropolitan area should be removed by gravitation, and that the sewage from 38 square miles only should be pumped. They proposed to place the outfalls in Sea Reach, where the sewage could be turned at once into rapidly flowing deep water, and to convey it to these outfalls in main outfall channels, designed in a tidal form, to facilitate their rapid discharge at low water, in which use should be made of water from the river near the metropolis to assist the flow, and to dilute the sewage: under which conditions of dilution and flow through these long channels it would arrive at the outfalls in Sea Reach in a comparatively innocuous condition, and thus all necessity of treatment with chemicals would be avoided.

The Metropolitan Board demurred to the extra expense involved in this alternative scheme; and whilst the question was still under the consideration of the Commissioners of H.M. Works a change of Government occurred, and the new Government decided to solve the question by relieving the Commissioner of Works from the duty of approving of the plans of the Metropolitan Board of Works, on the principle that, as the latter were to pay for the works, they should select what plan of removal they desired; thus ignoring the question as to how the River Thames outside the metropolitan boundary would be affected thereby.

That the criticisms of the referees in regard to the inadequate provision for the sewage and rainfall were justified is apparent from the Report of the Royal Commission on the Metropolitan Sewage Discharge, which reported in 1884, that "the floodings from heavy storms of rain which have occurred on several occasions in recent years in some of the populous suburbs of London, principally those on a low level, made it necessary for the Board to determine upon the construction of some additional large sewers to carry off the storm water. These sewers have storm outlets into the Thames, and Sir Joseph Bazalgette estimated their cost at £1,500,000." And the same report says that it was found necessary to enlarge the reservoirs at Barking and Crossness, at a cost of £160,000, so as to prevent the necessity for turning so much of the sewage into the river during the flood tide.

The Royal Commissioners on Metropolitan Sewage Discharge further show that the plan of turning crude sewage into the river at Barking and Crossness has resulted in serious injury to the purity of the Thames. They go on to state that in dry seasons the dilution of the sewage is scanty and ineffective; and that there is evidence of evil effects on the health of persons employed on the river. That in hot and dry weather there is a serious nuisance and inconvenience, extending to a considerable distance both below and above the outfalls, from the foul state of the water consequent on the sewage discharge; the smell is very offensive, and the water is at times unusable. Moreover, that foul mud, partly composed of sewage matter, accumulates at Erith and elsewhere, and adheres to nets, anchors, and other objects dropped into it; and that sand dredged near the outfalls, which used to be obtained in a pure state, is now found to be so much contaminated with sewage matter as to be unusable. They also mentioned that, in consequence of the sewage discharge, fish have disappeared from the Thames for a distance of some 15 miles below the outfalls, and for a considerable distance above them. They concluded that the river is not in the state in

which such an important highway to a great capital, carrying so large a traffic, ought to be.

To remedy these evils, the Royal Commissioners propose that a process of deposition or precipitation should be used to separate the solids from the liquids. To carry out their suggestion large reservoirs are in process of construction at the outfalls, in which the sewage is to be mixed with chemicals, with a view to the precipitation of the solid matter. The system, when complete, will entail the necessity of disposing of a large quantity of sludge; and it has been suggested that this object can be best effected by removing the sludge in steam barges, and dropping it into the sea. Thus these outfalls have been condemned by independent inquiries. The persistent attempts made by the Metropolitan Board of Works to maintain them in this part of the river have led to a very large expenditure; and the question is now left by the Metropolitan Board of Works as a most unsatisfactory legacy to the County Council. The object to be attained is to deliver the sewage into the river comparatively free from those conditions which cause it to render the river offensive. The proposed precipitation by chemicals leaves a large amount of sludge to be carried away, and involves a considerable and continuously increasing expenditure in chemicals and labonr.

Sir Henry Roscoe, who has been consulted by the Metropolitan Board of Works in connection with this method of sewage purification, says, in one of his Reports :—

"Even should the chemical treatment, as proposed, be adopted for the whole of the sewage of the metropolis, and if, moreover, it should be proved practicable to carry out the whole of the sludge to sea, I still lean to the opinion, looking to the question of the *permanent* disposal of the sewage, that the sewage, whether previously clarified or not, must either be filtered through land, or discharged into the estuary at a point not higher than the Sea-Reach."

And he goes on to point out that there is another direction in which the purification of the sewage can be sought for, viz., by supplying oxygen to the sewage, by means of the development of animal and plant life in the sewage; and he suggests that deodorants and precipitation should be looked upon only as a temporary expedient. Sir Henry Roscoe says :—

"The purification of the river is chiefly effected by living organisms, requiring free oxygen for their growth. These may be said to effect the changes generally ascribed to animal life. But other organisms of a vegetable character, such as algæ, &c., are always present in river water. These evolve oxygen during their life, and they are also potent instruments in the natural purification of the river; indeed, they are capable of oxygenating the water far above its normal amount, and thus aiding in supporting the life and growth of the former class of organisms. Both forms, therefore, assist each other in ridding the water of dead organic matter, both soluble and insoluble, and thereby bringing it into a healthy condition."

Similar changes take place in sewage during its flow through long channels, especially when exposed to the air and light; and this is the reason why sewage possesses a comparatively small manurial value when applied to land at a considerable distance from the place of its origin. Sir Henry Roscoe, moreover, suggests in one of his reports, that it might possibly be more economical to pump air into the sewage, and thus supply it with oxygen, rather than to resort to treatment with chemicals.

The referees for the main drainage proposed in 1858, that the sewage should be simply diluted with water from the Thames, and carried a distance of from 18 to 20 miles down to Sea Reach in channels, open where practicable, and constructed so as to assist the aeration of the sewage during its flow, and they contended that it would arrive at Sea Reach in a practically innocuous condition, or at any rate in such a condition as to mix with the larger volume of water in Sea Reach without creating any nuisance or injury to the river.

This recommendation was derived from their examination of narrow rivers which had been rendered exceedingly foul by town sewage at one point of their course, yet on arriving a few miles lower down were found to be comparatively clear; and this view is now corroborated by Sir H. Roscoe's recent reports.

The question which is now left to the London County Council to decide is whether they shall continue the use of deodorants, involving the removal of large quantities of sludge in barges to the sea, or whether they will follow the suggestions of Sir Henry Roscoe's reports, to aerate or oxygenate the sewage, in order to encourage the growth of healthy organisms, and thereby rid the water of dead organic matter, and thus bring it into a healthy condition.

Medical Officers of Health.—The duties to which I have alluded are those which the London County Council has inherited from the Metropolitan Board of Works. There are

other duties which have more of a permissive character; and of these, one of the most important is that of the creation of the office of medical officer of health, or medical adviser to the County Council, a step which has already been resolved upon. This officer has no direct executive functions connected with sanitation, but he must derive his knowledge of the sanitary condition of the metropolis from the local medical officers of health and from the registrars.

The medical officers of health of Vestries and District Boards are bound to send annual reports on the sanitary state of their districts to the County Council: and also to transmit to them copies of any special reports; and they are also to give information to the County Council of any outbreak of dangerous epidemic disease. Thus the medical officer of the County Council will be able to prepare full reports upon the health of the metropolis.

This is the first step towards the formation of a Sanitary Department of the County Council. The next step will be to bring under its more direct action the services which watch over the purity of water, of food, of gas, and of the atmosphere.

Notification of Infectious Disease.—One of the most important sanitary matters which it is incumbent upon the County Council to urge on the Legislature, with a view to maintaining the health of the metropolis, is the enforcement of compulsory notification of infectious diseases. In the metropolis, this question is of especial moment. At the rate of increase which has been steadily maintained since the beginning of this century, the population will in another twenty years amount to probably 6,000,000.

During the last severe epidemic of small-pox, which began in 1884 and ended in 1885, the Metropolitan Asylums Board arranged to remove all cases of small-pox from within the metropolis, and treat them away from the population. The system now in force is to convey the patients by ambulance carriages and ambulance steamers to hospital ships in the river, at Long Reach, 20 miles below London-bridge.

At the present time there is very little, if any, small-pox in the metropolis, and we may assume that this is in some degree the result of the action of the Metropolitan Asylums Board in at once removing all cases from the midst of the population. But the progress which we have thus made in checking infectious disease is an evidence that we ought not to be content with what we have already done. For the metropolis, with its daily-increasing population, is subject to a continually increasing risk from infectious disease. The notification of disease, the isolation of all patients, whether rich or poor, the careful observation of all those who have been in contact with the patient, the disinfection of the house in which the patient resided at the time of his attack, and the removal of any sanitary defects which may be found in the house, are necessary for preventing the spread of small-pox and other infectious diseases. But in order to make the working of such a law thoroughly effectual, as well as for securing the due enforcement of many other matters connected with the health of the metropolis, it is essential that all the sanitary services of the metropolis, including the Metropolitan Asylums Board, should be brought more under the influence of the London County Council than is now the case.

I have thus briefly alluded to the main sanitary functions which fall immediately within the duties of the London County Council. Many others will be laid on it in time. For instance, the water-supply of the metropolis will soon become a burning question. But the matters which press most immediately for action are those relating to the revision of the Building Acts in their sanitary aspect, especially in relation to securing the purity of the atmosphere, and efficient circulation of air; the housing of the poorer classes, the disposal of the sewage in such a manner as not to injure the purity of the Thames, and the compulsory notification of infectious disease, concurrently with a properly organised sanitary service.

Conclusion.

In this paper time has not permitted me to do more than indicate briefly the principal functions of County Councils in matters relating to health. A long chapter could be written upon the details of each of these functions. I think, however, that I have here stated enough to show what a large influence upon the social well-being of the country will be exercised by this edifice of local government of which Mr. Ritchie laid the foundation in the County Councils, and of which we await with interest the plan which he has promised for the superstructure.

DISCUSSION.

Surgeon-Major Ince, M.D., said he must take exception to the phrase "sanitary science," as he considered the proper term to use was "sanitary

theory." There appeared to be at the present time a sanitary mania, and he was glad to see a nobleman occupying the chair who was a member of that body which would before long have a voice in controlling the enormous waste of money on so-called sanitary science. One of the main objects of sanitarians was to obtain pure water, but was there such a thing in Nature as pure water? Then it was said that sewage was very dangerous to the health of the community, but this was an assertion which rested on no logical proof. If sewage was so dangerous as sanitarians would lead them to believe, the human race ought to have been extinguished ages ago.

Mr. T. C. Townsend said he thought the observations of Sir Douglas Galton did not apply exclusively to the County Council of London, but applied to the community at large, to the local districts throughout the whole kingdom. The want of the rural districts was a proper system of drainage, and a proper supply of water. You could not always get a proper supply of water, for the reason that this was not always to be commanded, but with proper appliances water could be purified.

Mr. Charles R. White said there was no doubt that the River Thames was in a very impure condition, and the question for the County Council to consider was how this might be remedied. He had hoped that the reader of the paper would have thrown some light upon this matter. The sewage question was an important one, and as the component parts of sewage were of some value, he should have thought it might be utilised for agricultural purposes. One great evil was the overcrowding in the dwellings of the working classes, and the insanitary condition of the houses, and this subject would no doubt receive consideration at the hands of the County Council. He suggested that a register should be kept of the number of inmates in each house.

Mr. W. S. Brough said there was one difficulty which might arise in country districts where there was pollution of the rivers. It was difficult to make the rural sanitary authorities move in this matter, but if the County Council had power to take the matter in their own hands, and to institute proceedings, and they did so, it would be most agreeable to the authorities, because on the County Council would fall the greater part of the expense.

Mr. Alexander Payne was of opinion that during the last few years there had been great progress in sanitary science. At one time drains were imperfectly laid; but now, owing to this improvement, drains were made of materials which did not leak, and the emanations of sewer gas had been prevented. When a gentleman connected with the medical profession said there was no such thing as sanitary science, he thought the remark should be met with a strong protest from that meeting. In his opinion sanitary science had made enormous strides, and now that they had a new authority in London and the country, he hoped that this science would be more known, and that competent persons would be appointed to see that the work was properly carried out.

Mr. Scovell said he had paid considerable attention to the administration of public affairs in London, and having been a vestryman for some twenty years, he had some knowledge of what might be termed the seamy side of sanitation. Sir Douglas Galton had done no more than justice to Mr. Ritchie in eulogising his work, but his own feeling was that the greatest benefit would not be derived so much from the creation by an Act of Parliament of an improved piece of mechanism or organisation, as from the development of public interest in matters of public administration. He was speaking simply with regard to London. Hitherto nothing had been more remarkable than the excessive apathy of the population. This had not only been characteristic of the mass of the ratepayers, but even amongst men of public spirit there had been a want of men who were able to grasp the wants of the metropolis as a whole. There were excellent men in different parishes, but there was an absolute dearth of men who were capable of dealing with the metropolis as a whole, and this had been accompanied by a process of division into two classes, viz., the rich and the poor. Circumstances had led to these classes being divided more and more; the East-end of London was very poor, and the West-end was filled with well-to-do people, while in the centre was found the wealth of the universe. The construction of the County Council for London for the first time enabled men from all parts of London to meet and discuss the affairs of the metropolis as a whole. It was quite certain that the sanitation of the metropolis could only be carried out at a large expenditure. The Metropolitan Board of Works had been hampered by limited ideas of expenditure, but he hoped the new Council would take a broader grasp of finance. The members of the Board had tried to keep the rate down to sixpence in the £, but this would not do for the new Council. The Council should not be afraid of laying out sums which might at first sight appear enormous, for it was better to do this and do the work well than to fritter the money away on foolish experiments. The Metropolitan Board of Works had been penny wise and pound foolish, and the County Council ought to rise above such a shopkeeper's way of looking at finance. He was of opinion that the most appalling waste was in the low condition of vitality and health among the population, and he considered that if we were in a better state of health London would be an infinitely richer city.

Dr. Dudfield said the range of subjects dealt with in the paper was so wide that it was impossible to

discuss them in the time allotted. Sir Douglas Galton wished the Council had power to deal with the question of sanitation from "sink to sewer," but this power they did possess under the Act, and he hoped they would exercise it. The question of housing the working classes was one which ought seriously to be taken in hand, and good work might be done in this direction, though of course it would have to be paid for. Torrens's Acts were very complicated and difficult to work, and they would want consolidation and amendment before they could be of any great service. He should like to see Lord Shaftesbury's Act put in force. The County Council, like the Metropolitan Board of Works, had power to inquire into the state of an insanitary area, to clear it, make roads, and sell the site for what it would fetch; and, in one instance where this had been done by the old Board, the net cost to the metropolis, owing to the large sum paid for prospective value, was £1,500,000 sterling. It would have been cheaper to have provided mansions for the poor outside London, and to have made them a present of the houses when built, than to do what had been done. There was no doubt that insanitary areas should be cleared, but this ought to be done at one-third the cost which had hitherto been paid. He thought however great and admirable the central body might be, it was impossible for one body to govern the whole of London. The central body should be legislative, and make bye-laws for the executive bodies, but he thought they could never get on properly in London without having local bodies. The whole administration of London might be so arranged that the same description of work should be done in the same manner, under rules laid down by a central body capable of legislating.

The CHAIRMAN said the paper had covered a most important field. Such subjects as water, food, and drugs; houses, rivers, and drainage, were questions any one of which would form sufficient matter for an evening's discussion. The great end which the paper had answered was to show what a very large field of administration had been brought within the scope of local government, both in London and in the country. There could not be a doubt that the measure of 1888 had commenced an enormous era of change. For the first time we had got the whole male population of the country practically represented—not only, as it had hitherto been, in Parliament, for political purposes, but represented for all those purposes which entered into its daily life. There was no doubt that the poorer part of the population suffered from very great, and to some extent preventible, evils, which would no doubt form the subject of deliberation in the County Council. If they were at all inclined to neglect those questions, every three years the remedy was in the hands of the electors. Therefore they might consider that not only was machinery provided, but a very great impetus behind that machinery was secured. The work of the County Council might be described shortly as a combat of science and good information against adverse circumstances, and in proportion as the circumstances were adverse, so were more and more the means of resistance and triumphing over these difficulties likely to be developed. It was worth noticing the statesmen who had been connected with these measures. In Lord Shaftesbury, Mr. Torrens, Lord Cross, and Mr. Ritchie they had a good representation of all the political parties in the country; and the action of political parties represented not only the conviction of individual statesmen, but the pressure of public opinion which made it worth the while of political parties to give precedence to one question over another. The very list of statesmen was an indication of what very great progress this question had been making. As regarded the particular function of the County Council in sanitary matters, he was a most inadequate representative, because his duty in connection with it was almost exclusively of a financial nature. There was one caution, however, which it would be well for all sanitary reformers to bear in mind. Sanitary reform was a very costly operation, and ratepayers had a limited purse and a still more limited patience. The continuity of sanitary measures very much depended on the prudence with which they were inagurated and conducted. There should be well matured schemes consistently and persistently maintained, but too great a call on the ratepayers should not be made in the early years. The great chance of these measures being successful was in their being supported by a great mass of public opinion, and on that they might rely if the measures in themselves were well conceived and were prudently pursued. The paper showed what a large field was open, and the publication of it would promote the cause which the meeting had at heart, and it would also reflect very considerable credit upon the Society. In conclusion, he begged leave to propose a hearty vote of thanks to Sir Douglas Galton.

The motion was carried unanimously, and having been briefly acknowledged, the meeting adjourned.

Miscellaneous.

THE PARIS EXHIBITION.

The British Section still appears to be the most advanced in the Exhibition, the work in the other parts of which generally is somewhat behindhand. It is difficult to think that the French sections will be anything like ready by May 6. The General British Court will certainly be tolerably complete.

In the machinery-hall there has been great delay, in consequence of the building not being sufficiently advanced; and, indeed, much of the work which ought to have been done months ago by the French authorities is not finished yet. The appearance that the machinery-hall will present on the day of opening it is difficult to say; at all events, this country will be as far advanced as any body else. The fact that part of the building of the liberal arts had to be reconstructed will make this section also somewhat backward. As the end of the building where the British exhibits will be is not entirely completed, it is impossible to believe that this can be ready for the opening. In the food products and agricultural galleries a great deal of work in completing the buildings has to be done by the British Committee, but there is no reason to doubt that these will be in time. The part of the building where the retrospective exhibits will be placed is being pushed on with, and is almost fit for their reception. The completion of the structure of the Eiffel Tower, on 31st March, was celebrated by the firing of guns from the top, and the hoisting of flags. A sailor, who swarmed up the flag-pole at the top to reeve the halyards for the flag, must have the satisfaction of knowing that he has been further from the surface of the earth, on a building made by man, than any other human being since the world began. The French authorities have at last decided upon juries and awards. The juries of classes will commence their labours on June 1, and must be prepared to hand in reports to the juries of groups by July 15, who, in their turn, must report to the grand jury not later than the middle of August. The awards will be distributed in September. The total number of jurymen for all classes is not to exceed 900.—*Engineering*.

Correspondence.

THE KHOJA OR ISMAILI MUSSULMAN.

On the occasion of the reading of Mr. H. H. Johnston's exceedingly comprehensive paper on "The Asiatic Colonisation of East Africa" (reported in the *Journal* of Feb. 1, No. 1,889), some of us took exception to certain incidental statements he made regarding the Khoja community at Zanzibar, and on the East Coast generally. These chiefly implied that the Khojas are still, as some generations ago, so fanatically devoted to their P'ir, or spiritual head, H. H. Aga Khan, of Bombay, as to make them obstinate opponents of popular education, and addicted to the use of the poisoned bowl on behalf of the Aga Khan's personal treasury or tribute. These rather ancient imputations were contradicted in the discussion that followed, and as Mr. Johnston himself allowed for large exceptions, no great harm could be done. But, as the matter has attracted some attention at Bombay, it may be well to republish in the *Journal* the refutation, as subjoined, and the more so as it has been put forward by the notable Khoja merchant to whom Mr. Johnston referred, with due respect, on his appearance at Windsor a few years ago, forming a link with the far off times of Richard Cœur de Lion.

W. MARTIN WOOD.

Brook-green.

"THE ZANZIBAR KHOJAS.

"*To the Editor of the 'Bombay Gazette.'*

"SIR,—Our client, Mr. Tharia Topan, has read with considerable pain your issues of the 20th and 23rd ultimo, in which you refer to, and publish extracts from, a lecture read by Mr. Johnston, Her Majesty's Consul at Mozambique, before the Indian Section of the Arts Society in England on the subject of the Khojas of Zanzibar. Our client's name is prominently mentioned in this lecture, and he wishes most strenuously to deny that secret poisoning does exist amongst the Khoja community in Zanzibar, or that certain members of the Khoja community in Zanzibar, soon after making wills in favour of H. H. Aga Khan, have been poisoned. Our client informs us that he has never even heard of a suspicion of any Khoja being poisoned. Under such circumstances the statement is wholly devoid of truth, and is a disgraceful libel on the Khoja community of Zanzibar.

"The paragraph further on states that our client some time ago gave £20,000 for the purpose of founding a school at Zanzibar, but H. H. Aga Khan indirectly intervened, and forced our client to turn the school into a hospital. Our client wishes us to state that H. H. Aga Khan did not in any way, either directly or indirectly, intervene, and that it is not true that H. H. Aga Khan was strongly opposed to the spread of education.

"Our client wishes that you will give prominence to the denial he has instructed us to make.

"Yours, &c.,

"PAYNE, GILBERT, AND SAYANI."

On this letter the *Bombay Gazette* (summary) of March 15th, thus remarks:—"In commenting the other day upon the interesting paper on the Indian settlers in East Africa, which the British Consul in Mozambique lately read before the Society of Arts, we called in question that part of Mr. Johnston's statements which relates to the Khojas in Zanzibar, and we invited the members of the community in Bombay to deal with some passages in the paper in which obvious injustice was done to their brethren in Zanzibar. Mr. Tharia Topan, an enterprising and respected Khoja, who has for many years had intimate commercial relations with Africa, addresses us a letter flatly contradicting the particular statements upon which we ourselves had cast doubt,

notably the accusation that the Zanzibar Khojas have a habit of being taken ill, under a suspicion of being poisoned, after they have made their wills in favour of the Aga Khan. It is not inappropriate to mention that in Bombay, where there are many more Khojas than in Zanzibar, and where the influence of their spiritual leader must be more direct, and at least as powerful as on the other side of the Indian Ocean, nothing is heard of any such suspicion, and the Khojas have as good a name amongst us as any of their Mahomedan brethren. Mr. Tharia Topan also confirms the contradiction which we were able to give, from our own knowledge, of Mr. Johnston's statement that the Aga Khan is strongly opposed to the spread of education amongst his community. The specific instance which Mr. Johnston alleged in support of this charge, namely, that the Aga had made Mr. Tharia Topan divert to another purpose £20,000 which that gentleman had offered for a school, is denied emphatically by Mr. Tharia Topan himself, whose contradiction settles that question."

INDIAN AGRICULTURE.

Permit me to say, in reference to the communication from Major-General Michael, that the opinion I expressed on the subject of European ploughs, and forms of so-called "improved" ploughs, was given in full knowledge of the contents of the report which he quotes, and after I had not only seen but worked with my own hands many of the most important forms of Indian ploughs, as well as those offered by implement manufacturers as improvements upon the native ploughs. My views on this matter are not the result of casual observation, but of careful investigation of the methods of working land in India. The opinions I have on several occasions publicly expressed are identical with those I now hold, viz., that it would be ruinous to turn up wet land in a hot sun with any form of plough—and most of the land now under cultivation is worked while wet. The only places where the mould-board ploughs have proved successful—and I have fully admitted the fact—is in the case of exceptionally dry or light soil, or in that of rice cultivation, where it is worked under water. At Shiyali, on one estate, I found 150 improved ploughs employed on rice land and doing the work admirably. But the two conditions under which success is possible are so little met with, that we may at once leave them out of the question when speaking of India generally. Local success to the extent of even a few hundreds of ploughs, under exceptional circumstances, does not touch the great question of their suitability to the prevailing conditions of our Eastern Empire. I am quite prepared to accept the decision which will naturally be given in a few years, as the result of experience. I do not submit that nothing can be done to improve native implements, because they are capable of very great improvement; but what I do feel, and also think it my duty to communicate, is that the principle of the native plough is the one to follow, and that involved in the European plough is the one to be avoided.

ROBERT WALLACE,
Professor of Agriculture and Rural Economy in the University of Edinburgh.

Obituary.

DUKE OF BUCKINGHAM AND CHANDOS, G.C.S.I.—The Duke of Buckingham, who died on Tuesday, 26th March, at Chandos-house, had been a member of the Society of Arts since 1860. He presided at the meeting of the Society on November 26, 1886, when Mr. Ernest Hart read a paper on the International Health Exhibition, and in 1885 he was elected a vice-president. His Grace had consented to preside at the meeting of the Indian Section, on 8th March last, when Professor Wallace read his paper on Indian agriculture, but he was prevented attending by the illness which so soon afterwards terminated fatally. The Duke of Buckingham was born in 1823, and held the office of chairman of the London and North-Western Railway Company from 1853 to 1861, when he succeeded his father as third Duke. He was appointed Governor of Madras in 1875, and held that office until 1880. In 1884 he was chairman of the Executive Council of the International Health Exhibition, and at the time of his death he was chairman of committees of the House of Lords.

MICHEL CHEVREUL.—Michel Eugène Chevreul, member of the Institute of France, and foreign member of the Royal Society, the eminent chemist, who died on the 9th inst., at the great age of 102, received the Albert Medal of the Society of Arts, in 1873, "for his chemical researches, especially in reference to saponification, dyeing, agriculture and natural history, which for more than half a century have exercised a wide influence on the industrial arts of the world."

General Notes.

PRODUCTION OF BEER IN AUSTRIA.—According to a recent statistical return, 12,486,407 hectolitres (hectolitre = 22 imperial gallons) of beer were produced last year in Austria, Bosnia, and Herzegovina, a falling off of 190,019 hectolitres as compared with 1887. The exports, however, increased by 9,087 hectolitres, having amounted to a total of 250,963 hectolitres.

Silk Industry of Greece.—After having experienced a period of great prosperity, the silk industry in Greece, says the *Journal de la Chambre de Commerce de Constantinople*, is now in a depressed condition. The production of cocoons, which in 1855 amounted to between 1,200,000 and 1,400,000 kilogrammes, fell in the period comprised between 1870 and 1880 to about 500,000 kilogrammes. Since the year 1884, this quantity has still further decreased, and the production, which is centred in the south of the Peloponnesus, in Messenia and Laconia, did not exceed 200,000 kilogrammes of cocoons, that is to say a yield in silk of about 18,000 kilogrammes, of which about 10,000 kilogrammes are exported. This diminution must be attributed to the disease of the silkworms and to the low price of cocoons. Almost all the cocoons and silks from Greece are shipped to Marseilles, and Calamata is the principal port for shipment.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday evenings at Eight o'clock:—

Papers to be read at meetings after Easter:—

"Secondary Batteries." By W. H. Preece, F.R.S.

"Origin and Manufacture of Playing Cards." By George Clulow.

"The Use of Spirit as an Agent in Prime Movers." By A. F. Yarrow.

"Automatic Selling Machines." By J. G. Lorrain.

Applied Art Section.

Tuesday evenings, at Eight o'clock:—

May 14.—"Venetian Glass." By Dr. Salviati.

Foreign and Colonial Section.

Tuesday evenings, at Eight o'clock:—

April 30.—"A New Ocean Route to Siberia." By Captain Wiggins, F.R.G.S.

Indian Section.

Friday evenings, at Eight o'clock:—

May 3.—"The Karun as a Trade Route." By Major-General Sir R. Murdoch Smith, K.C.M.G. Sir Lepel Griffin, K.C.S.I., will preside.

May 24.—"Indian Wheats." By John McDougall. J. M. Maclean, M.P., will preside.

Cantor Lectures.

The following courses of Cantor Lectures will be delivered on Monday evenings at Eight o'clock:—

C. V. Boys, F.R.S., "Instruments for the Measurement of Radiant Heat." Four Lectures.

Lecture IV.—April 15.—D'Arsonval's thermo-galvanometer—Boys' radio-micrometer—Application of the theory of the instrument to find the best proportions—Modification for showing vertical tremors—Spinning thermo-piles—Instruments depending on change of resistance—Langley's *bolometer*—Advantages and disadvantages of different instruments compared.

H. Graham Harris, M.Inst.C.E., "Heat Engines other than Steam." Four Lectures.

May 6, 13, 20, 27.

MEETINGS FOR THE ENSUING WEEK.

Monday, April 15...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. C. V. Boys, "Instruments for the Measurement of Radiant Heat." (Lecture IV.)

Victoria Institute, 7, Adelphi-terrace, W.C., 8 p.m. Dr. Gordon, "The Ethnology and Ancient Chronology of China."

Tuesday, April 16..Civil Engineers, 25, Great George street, S.W., 8 p.m. Discussion on Sir Nathaniel Barnaby's paper, "Armour for Ships."

Sanitary Institute, 74A, Margaret-street, W., 8 p.m. Mr. A. Wynter Blyth, "Sanitary Laws and Regulations Governing the Metropolis."

Zoological, 11, Hanover-square, W., 8½ p.m. 1. Mr. A. H. Everett, "The Zoo-geographical Relationships of the Island of Palawan and some adjacent Islands." 2. Mr. Oldfield Thomas, "Description of a new Genus of Muridæ allied to *Hydromys*." 3. Mr. Oldfield Thomas, "The Mammals of Mount Kina Balu, North Borneo." 4. Col. C. Swinhoe, "New Indian Lepidoptera, chiefly Heterocera"

Wednesday, April 17...Meteorological, 25, Great George-street, S.W., 7 p.m. 1. Dr. Robert Lawson, "The Deaths caused by Lightning in England and Wales from 1852 to 1880." 2. Mr. F. C. Bayard, "The Diurnal Range of the Barometer in Great Britain and Ireland." 3. Mr. A. W. Clayden, "Note on a Working Model of the Gulf Stream."

Geological, Burlington-house, W., 8 p.m. 1. Dr. Charles Callaway, "The Production of Secondary Minerals at Shear-zones in the Crystalline Rocks of the Malvern Hills." 2. Messrs. Grenville A. J. Cole and A. V. Jennings, "The Northern Slopes of Cader Idris."

Thursday, April 18...Linnean, Burlington-house, W., 8 p.m. 1. Dr. Maxwell T. Maxwell, "Conifers." 2. Mr. R. J. Harvey Gibson, "*Helcion pellucidum*."

Chemical, Burlington-house, W., 8 p.m. Dr. Armstrong, and Messrs. Holding, Percival, Rossiter, and Wynne, "Notes on Naphthaline Derivatives."

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FRIDAY, APRIL 19 1889.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CANTOR LECTURES.

The fourth and last lecture of the course on "Instruments for the Measurement of Radiant Heat," was delivered by Mr. C. V. Boys, F.R.S., on Monday evening, 15th inst.

On the motion of the Chairman (Professor Hughes, F.R.S.), a vote of thanks to the lecturer for his valuable lectures was passed unanimously.

The lectures will be printed in the *Journal* during the summer recess.

Proceedings of the Society.

FOREIGN & COLONIAL SECTION.

Tuesday, April 2, 1889; Hyde Clarke in the chair.

The paper read was—

THE ARGENTINE REPUBLIC.

By F. K. Smythies.

Historical.

The River Plate was discovered in 1515 by Juan Diaz de Solis, who was murdered by Indians near Maldonado. Twelve years later Sebastian Cabot arrived and sailed up to Paraguay, but found the Indians so hostile that he came down to the mouth of the Carcarañal, and built there Fort Sancti-Spiritus, returning to Spain in 1530. An officer named Pedro de Mendoza, having obtained permission to equip an expedition of 1,800 men at his own cost, landed at the Boca in 1535, and laid the first foundation of Buenos Ayres. He sent Juan de Ayalas to conquer Paraguay, who, after founding the city of Ascencion, the present capital of that republic, proceeded to open a route to Peru, but returning with silver from that country, Ayalas and his 200 followers were killed by Indians in the Chaco.

Meantime the Indians harassed Mendoza at Buenos Ayres so much that he sailed for Spain to procure reinforcements, and died on the voyage. The survivors removed from Buenos Ayres to Paraguay, which for more than two centuries was the head-quarters of the Spanish Government.

By the treaty of Utrecht, in 1713, the British obtained a monopoly for 30 years for importing African slaves into the river Plate, with right to establish a residence at Buenos Ayres; this was the origin of a settlement that has become, for its numbers, the most flourishing British community in the world.

The first English invasion was led by General Beresford in 1806, when the Spanish Viceroy fled to Cordoba, leaving 800 British troops masters of Buenos Ayres. Subsequently Beresford had to capitulate to the local militia, commanded by Colonel Liniers, and his soldiers were sent up into the interior to Cordoba, Mendoza, and San Juan; and many of the inhabitants of those provinces have marked English features, with light hair and grey eyes. In the following year General Auchmuty took Monte Video, but General Whitelock, with 10,000 men, failed to recover Buenos Ayres.

On the 25th May, 1810, Buenos Ayres threw off the yoke of Spain, and elected a Provisional Committee. Generals Belgrano, Alvear, and San Martin led the patriot armies, and Admiral Brown the fleet, and were continually victorious over the Spanish arms, until July 9th, 1816, when the Argentine Republic was declared independent. The Argentines then crossed the Andes, and helped to free Chili and Peru from the Spanish yoke. From that time till 1880, when the last revolution occurred, the history of the country is a series of civil wars, revolutions, and assassinations.

Political.

The form of Government is a Federal Republic, composed of the fourteen provinces. The President and Vice-President, who must be native born, are elected for six years, and cannot be re-elected unless after an interval of

six years. The established religion is the Roman Catholic, but any form of worship is permitted, and non-Catholics are eligible to Congress or public employment.

There are no prerogatives of birth, no titles, nor can slaves exist in the Republic. Foreigners may become citizens, and are then eligible to Congress. The National Government consists of President, Vice-President, five Ministers (Interior, Foreign Affairs, Finance, Instruction, and War), and two Houses—Senators and Deputies. Each province has a Government formed on a similar plan, making fifteen Governments for 5,000,000 inhabitants. It was this plurality of Governments that was the chief cause of the perpetual revolutions that earned for the Republic such a bad name in Europe. Each provincial Government had the power of calling out the national guard in its own province, and as each of the fourteen provinces elected a governor every four or five years, it happened that there was almost always a revolution going on somewhere, and often two or three. Except for a few assassinations, they were for the most part bloodless, and were taken off in the English papers in Buenos Ayres by such headings as the following:—"Revolution in Catarnarca; three days hard fighting; nobody hurt." At the same time, they did an immense amount of injury to the country by taking the men away from work, and demoralising them into the bargain.

When General Urquisa, Governor of Entre Rios, was murdered by a rebel named Lopez Jordan, his widow, who was immensely rich, devoted $6,000,000 to the purpose of taking Lopez Jordan dead or alive. The individual who was entrusted with this business kept it going like a lawsuit for several years, so that Madame Urquisa could not say that she did not get plenty for her money, the leader and his friends in the meantime of course pocketing the lion's share of the $6,000,000. This was done in many ways, by selling contracts, by charging for powder that was never burnt, and by keeping thousands of men on the books, drawing their pay and rations, while there were only a few hundred in reality, who got no pay and very little rations. Several of my own men were away for two or three years, taken away illegally to help at these questionable proceedings; but whether the Argentines learnt such tricks from the English whom they took prisoners under Whitelock and Beresford, or elsewhere, history does not relate.

All these revolutions were caused by the bad government of the Buenos Ayres or aristocratic party, who being averse to change, showed general apathy for the good of the country as long as they could remain in power, and a strong desire to shoot or hang anyone who did not agree with them.

But better times were at hand. As the Argentines had freed themselves from the grinding tyranny of the Spaniards, so the 13 provinces determined to free themselves from the dominant oppression of Buenos Ayres. With General Roca, fresh from conquering the Indians in Patagonia, at the head of an army of 30,000 men, they surrounded Buenos Ayres, and the Government were defeated at the battle of Coralito, and about 3,000 killed. The actual *casus belli* was the usual one, the Government wanted to make everyone vote at the point of the bayonet, in order that they might keep in power.

General Roca, being duly elected and installed as President in 1880, immediately got a law passed to nationalise the army, making it illegal for anyone but the National Executive Power to call out the National Guard.

Under the former governments, the settlements were raided by the Indians on the one hand, who stole cattle, horses, and sheep, and killed all who resisted them, and on the other hand perpetual revolutions disorganised the country and demoralised the people. General Roca captured the Indians, and put them on reservations; he nationalised the army, and so prevented revolutions. There have been several attempts at revolution in the provinces, but they have been put down with a strong hand by the National Government. The *modus operandi* consists of a special train, an interventor, and a few troops of the line, and in two days the revolution is snuffed out. As an example, here is a telegram, taken from the *Buenos Ayres Standard* of January 11th of this year:—

"Mendoza, January 9, 1889.

"Interventor Derqui forwarded the following telegram yesterday to Vice-President Pellegrini:—

'To the Vice-President:—I published to-day the decree of the National Government, declaring this province under national intervention, and I have assumed the command of affairs.

'I have appointed General Fotheringham commander of the troops of the line, and chief of police of the city.

'The militia that had been gathered I have ordered to be disbanded.

'With regard to the staff and officers here, General Fotheringham will act according to the instructions received.

'Any eventuality I shall immediately communicate to your Excellency.

'God guard your Excellency,

'M. DERQUI, *Interventor*.' "

At the next election for President, in 1885, the aristocratic party of Buenos Ayres tried to get up a revolution, to turn out the provincial party, and in order to provide the sinews of war they borrowed $800,000 from the Provincial Bank of Buenos Ayres. They did not make war; but they kept the sinews, and I believe the bank has never got them back. Another great cause of the revolutions was that it was one of the few ways by which the authorities had the handling of large sums of public money; but now-a-days they find they can do better by following in the paths of peace, and what with granting concessions for railways, ports, waterworks, and other public works, they find that they can make more than by getting up a revolution, and with less risk and trouble. The Argentines possess a fine country that wants improving, and it is hardly likely they are going to let foreigners make large fortunes without charging them a commission in some form or another. An Argentine politician always says he is bursting with patriotism, but even patriotism cannot be supported on starvation wages. Like most other good things in the country, political morality is growing and increasing, and the foreign element is setting a better example, both in commercial and political circles.

TRADE AND COMMERCE.

The Argentine Republic has a very large foreign trade in proportion to the number of its inhabitants, for the reason that it produces large quantities of raw material, and has at the same time very few manufactures. In 1887 the exports and imports amounted to £42,349,840, being equivalent to £9 13s. per inhabitant, against £8 8s. in France, £6 7s. in Germany, £6 in the United States, and £2 4s. in Russia.

Of the exports, those resulting from pastoral pursuits have, up to the present, given the largest returns, especially wool and hides, but in a very few years the products of agriculture will far surpass those of stock at the present rate of progression. The tendency lately has been to devote the land to growing corn instead of grazing stock, so much so that many of the finest grazing lands of Buenos Ayres are being let to Italian immigrants for agricultural purposes. Although at first sight it appears a doubtful policy to plough up grazing land equal in many instances to the finest English meadows, as the owners get from two to three times the rent for the land, I am afraid the power of the almighty dollar will be paramount. Although the Argentine Republic is, as a rule, unknown or ignored by the British farmer, all these changes very nearly affect him, as the amount of food products imported from there to Europe, already considerable, will be increased in the next few years by reason of the rapidly increasing immigration, and the extending of new railways. In England large areas of land are being changed from arable to grass, and in the Argentine the reverse process is in operation, but on a much more extensive scale. Modern science reduced to practice is at the bottom of many of the changes that occur in such practical pursuits as farming, and have a very far-reaching effect in the way of reducing to one level the value of land and what it produces all over the world. In this way, while land in England has gone down in value, in other parts land used for identical purposes, *i.e.*, the production of food, wool, &c., has been increasing, and will go on increasing in value until in the Colonies, and countries like the Argentine, we may see land used solely for farming purposes worth actually more per acre than farm land in England. There are many reasons that point to this result as a strong probability. The fact of distance from the European markets, and consequent freight, has been proved already to be a very small factor in the question; and as regards the Argentine Republic, the difference in the climate alone will eventually leave England far behind in the race.

Although we have here in England the best breeds of domestic animals, they have been produced, and are maintained, under adverse circumstances, as the climate is obviously too cold to be the best possible for the production and development of animal life, and the present result has only been obtained by a rare combination of energy and capital.

The few farm products that have not as yet been brought under the demon of competition, or very slightly so, such as hay and straw, will one by one be met by foreign produce, placed in the market at a lower price because produced in a climate more congenial to its growth than the English. Take hay, for instance. Steps are now being taken to introduce in the Argentine States compressed *alfalfa* (lucerne), which grows

most luxuriantly, and gives as much as nine crops in the year; under hydraulic pressure it is reduced to a reasonable bulk for shipment. I saw a specimen of it lately, and was told that one of the London omnibus companies would take, I think it was 1,000 tons a month. It is much sweeter than hay, and I dare say on that account more nutritious. It is being sown very extensively, even private individuals laying down as much as a square league in a year. Wheat straw, which at present is burnt directly after threshing, will probably be exported in the same compressed form in the near future. As Nature abhors a vacuum, the commercial spirit of the age abhors waste. Not long ago I required some native clover seed for sowing, and I saw some advertised in a Rosario paper by a German house. On inquiring where it came from, I was told from Germany. It appears it goes over in the burr in the wool, is combed out, and formerly used to be thrown away; but now is bagged up, shipped back again, and sold at about £15 a ton. It was none the worse for the double voyage, as it came up very well, and is growing now. This same burr used to be a great detriment to River Plate wool, and I once asked a large Bradford wool manufacturer (whom I met while travelling in the Highlands) about it, and as he informed me he used considerable quantities of it, I asked him particularly how it was that, while English wool had come down in value about one-half, River Plate wool had doubled in value. He said that there were two reasons; one was that light woollen materials were much more worn now, especially for ladies' dresses, and River Plate wool, being chiefly fine merino, is particularly adapted to their manufacture. The other reason was that someone discovered a process to get rid of the small hooks with which the burr sticks to the wool, and which are so formed that it was almost impossible to comb them out. The process, as well as I remember, is that these hooks or claws are woven into the cloth, which is then steeped in a weak solution of sulphuric acid, 6 parts of acid to 100 of water; the fabric is then put into a room heated to 240° Fahr., when the vegetable matter is all carbonised, and can be brushed out without the cloth being injured. The same gentleman also told me the reason why wool must be shipped home unwashed, having about 70 per cent. of grease and dirt in it. I had already seen large establishments in Buenos Ayres for washing wool by steam lying idle, and asked my friend what was the reason, and he informed me that wool should only be washed just before being used, as the grease keeps it elastic, and washed wool soon loses its elasticity, and gets brittle, which accounts for the apparent anomaly of paying freight on the 70 per cent. of dirt in it.

There are more sheep in the Argentine Republic than in any country in the world, the total being about 90,000,000; but it is extremely doubtful if they will increase in number, though in quality they are improving every year.

Of horned cattle there are about 18,000,000, but, except for improved breeds or graded cattle, the value to-day has declined to about the value of the hide, or about one-third their former price. Many large landowners who want to devote their land to agriculture do not know what to do with them. The cause is over-production, eighteen millions of cattle, five millions of inhabitants, and export almost stopped from various causes, such as the imposition of export duties and the abolition of slavery in Brazil, the slaves being large consumers of jerked beef; but once a negro is free, and is not compelled to work, he will live on fruit, vegetables, and fish, or anything that does not oblige him to labour. This fall in the value of horned cattle came quite suddenly, and those who had not foreseen it have lost severely. Though in most cases the rise in the value of land has more than made up for the fall in cattle, there are many large cattle estancias that do not pay working expenses. The annual increase of calves is generally calculated at about 25 to 30 per cent., and the only apparent outlet for the surplus is to take their hides off. The same fate has overtaken cattle ranching in the United States, where they have fallen to about one-half their former value. This retrograde movement in the cattle business also tells adversely on the English farmer, as it lessens the demand for pedigree stock to improve the large herds of America; the export of Herefords in particular being almost entirely stopped, whereas formerly it was a very lucrative business, so that while the advance of agriculture tells against the farmer, here the decline in cattle breeding also tells against him.

Wheat.—The difference in the method of working wheat in the two countries is striking. In the Argentine the principal farmers are Italians from Northern Italy, a hard-working, hard-living, agricultural race. They go out with little or no capital, but, with the help of

their friends out there, they take up 150 or 200 acres of land and build a sod hut, and set to to plough up their holding, for which they pay rent, in cash or in kind 10 to 12 per cent. of the crop, or 3s. an acre, being a common rental. Women and children all work; one may often see four or five ploughs in a string. First of all comes a lad of 12 years, with a yoke of oxen and a light plough with a broad share, then a girl a little older, then the old woman (*la vecchia*), and last of all the old man, so that he can keep a fatherly eye on his team, with a double furrow plough and two yoke of oxen. In this way, without paying any wages, he will turn over about six or seven acres a day, which would cost the English farmer a good deal of hard cash. In harvest time they use chiefly American headers for reaping, with a 16 or 18 foot cut, clearing 30 or 35 acres a day. The wheat passes over an endless canvas band straight into the cart which moves alongside, and goes right away to the stack, the whole work being done in the most wholesale, expeditious, and at the same time economical manner—very different from the English way of doing it.

Threshing.—The stacks are made in pairs in the field, and the steam thresher draws up between them, working first from one side, and then from the other. The threshers used are of the largest and most modern make, fitted with straw burners. The favourite makers are Ransome and Sims, and Clayton and Shuttleworth, while many other makers also send out machines, so that here we have combined all the elements of cheap production, fertile soil, fine climate, cheap land (which in quantity is practically unlimited), cheap labour, and the most modern and expeditious machinery, and last, but by no means least, we have all this almost within sight of the ocean steamer. Even the large capitalists are giving up growing wheat because they cannot compete with the Italians, although they have all the advantages of capital, steam ploughs, and individual smartness, and grow as much as 13,000 acres of corn under one management.

River Plate wheat and maize fetch about the top prices in the European markets, the wheat flour possessing certain qualities of lightness which millers find admirably adapted for mixing with heavier home-grown wheats. The spread of agriculture into the interior is found to improve the climate by increasing the rainfall, as has also occurred, I believe, in India, and although there are well-known scientific reasons for this, it makes it none the less satisfactory to see it reduced to practice.

The agricultural labourer in this country has been taught to consider himself an ill-used, overworked, and down-trodden individual. He should compare himself with an Italian wheat-grower in the Argentine, working often 14 or 15 hours a day, and his children as well, and living almost entirely on what he raises, bread and sausage being his idea of gastronomic bliss. The agricultural labourer in England is living on the farmer, the farmer on his capital. Although foreign competition with English farm produce was of very slow growth, those chiefly interested took no efficient steps to meet the difficulty, but waited, like Mr. Micawber, for something to turn up in their favour; some trusting to protection, others to a foreign war, or natural increase of population, and even now those high in authority still talk of the present depression through which agriculture is passing, in face of the fact that here we have a country nearly twenty times as large as England and Wales, the greater part of which is being devoted to raising food for the European market, under conditions which puts competition on the part of England out of the question.

The only remedies I can suggest for what appears to be inevitable are for the young men to emigrate to the Argentine, and for the old ones to buy land there. Almost every Englishman out there now is making his pile, and nearly everyone who goes out for a pleasure trip buys land, although he had no intention of doing so when he started. You may ask—"And the girls, what can we do with our girls?" Let them emigrate too, for, as nearly all the young men are making money, they naturally want to marry, and many of them marry socially beneath them because there are so few girls of an equal status and education for them to choose from.

Land has gone up in value a great deal lately, both in the country and in the towns; but the price is based chiefly on the rental that can be got for it, and is still much below land in other countries used for the same purposes. Land in Santa Fé has gone up to fifteen to twenty times its value of six or seven years ago, and building land in Rosario has gone up ten times in the last two years. We have many advantages over the United States for raising corn and other produce, as the prairie land is situated on the seaboard, and along the Parana, which is navigated by large ocean steamers as far up as Santa Fé, or about 700

miles from the mouth of the river, so that an immense quantity of corn is raised within 100 miles of the ocean and river ports, whereas in the United States most of the corn being raised in the west has to be freighted from 2,000 to 3,000 miles overland, which is very expensive.

Argentine Railways.

There are about 5,000 miles of railways working in the Republic, and concessions granted for nearly as much more. Most of the older railways have been paying good dividends for years past, especially the main trunk lines; some of the short pettifogging lines having followed the usual course of such things in other countries, and paid little or nothing to the shareholders, unless guaranteed by Government. A period of very severe competition has commenced, and the older lines will have to look well to the order of their going, as for many years they had a virtual monopoly of the traffic, and paid big dividends; but, like all monopolists, they thought this state of thing was going to last, and some of them woke up rather late to the situation, and let other newer lines creep in where they should have made themselves masters of the situation. It is not only in England that capital is being found to build new lines and buy up existing ones, as both France and Germany are figuring largely in the concession list. The Fines Lille, a wealthy French company, has bought up all the Government Railways in Santa Fé, and has also obtained from the same Government all the concessions for new railways within the province, so as to make one united system, although the existing private railways cannot, of course, be touched, as their contracts must be respected. A German syndicate, according to the papers, made a similar offer for the provincial railways in Buenos Ayres, but the negociations fell through. The thought immediately occurs to one, "Why do not the English do these things?" There is plenty of money for investment in England. Perhaps the foreigner is more willing to pay a good commission for a good thing. All this points to the fact that there is a vast amount of capital ready to go into railways, and the National and Provincial Governments are able and willing to grant concessions, so that we may conclude that the days of monopoly, high freights, and big dividends are numbered; and that although the traffic, on account of largely increased grain production and other causes, will be very much increased, competition in the end will bring down dividends to the ordinary level, as it has done in the United States.

The Paper Dollar.

A vast amount has been written on the very intricate question of the depreciation of the paper currency, and while no one upholds it as a positive advantage, we must remember that it is common to many other countries besides the Argentine Republic, viz., Austria, Russia, Chili, and Brazil. Also, that while the actual currency is paper, sales and purchases are really calculated on a gold basis, and many of the most important transactions are actually effected in gold dollars or their equivalent, such as gold cheques or bills. All business houses and banks keep accounts in both gold and paper. As regards the future of the paper currency it is hard to prognosticate, but if the financial policy of the Government is sound, and produce, which is all gold value in Europe, continues to be exported at the present rate of increase, there seems to be no reason why the paper dollar should not gradually improve, and eventually come to par. At all events, if the exports of the country increase as they promise to do, there should be no fears for the financial position of the future.

Argentine Borrowings.

There has also been a good deal written lately in all the leading papers, financial and otherwise, about the large amount of Argentine borrowings, and a good deal of ignorance displayed in many articles as regards the resources of the Republic. For instance, one article closes with the following remark:—"Who among the most sanguine friends of the Argentine Republic will say its four millions of inhabitants, *mostly Indians*, are safe debtors for £25 per head?" How does the writer of that article suppose that the four millions is arrived at? Presumably, and as a matter of fact, by taking a census. But as there are not 5,000 tame Indians in the Republic, the ones he speaks about must be wild. How would he schedule a wild Indian with an 18 ft. lance between them? I am afraid there would be a vacancy on the staff of that paper. The writer has apparently fallen into the common error of making no distinction between Indians and Argentines, for which the latter will not feel much flattered. As for Argentine indebtedness, the resources of the country are so great, and her trade is in-

creasing so rapidly, now that the incubus of bad government has been removed, that she is quite good for both the capital and interest. That she would not borrow too much it she were allowed, I do not say; but that is really such a common fault, that it would be injudicious to commit oneself. She is very well able to pay the interest on what she already has.

The following figures show, in round numbers, the rate at which her trade is progressing.

Imports.	Dollars.
1880	45,000,000
1887	117,000,000
Exports.	
1880	58,000,000
1887	84,000,000
Total Foreign Trade.	
1887	201,000,000
1888. Estimated. Returns not yet published	250,000,000

To show the growth of agriculture in the Republic, we will take the returns of wheat exported in 1878 and 1887:—

1878	2,500,000 kilos, about		2,500 tons.
1887	237,865,000 ,,	,,	237,865 ,,

The export of maize has grown even more, being for:—

1878	17,000 tons.
1887	361,841 ,,

Besides the above amount of grain exported, the home consumption has increased very largely, but this is only the commencement of what promises, in the near future, to be one of the largest grain traffics the world has ever seen.

Minerals.

Minerals and mineral ores form a considerable item of industry in, and export from, the Republic. Ores are brought even from Bolivia, and shipped from Rosario to Liverpool, and other ports in Europe. This bu si ness is also in its infancy, as although there are some very rich mines being worked, such as the Famatina silver mines, the greater part of the mountainous districts, especially in the Andes, have not been explored yet. A few years ago, I went with a friend on an excursion to the Upper Provinces, *i.e.*, Mendoza, San Luis, and San Juan. Mendoza, the city of earthquakes, is one of the most beautiful places imaginable. In the new town, built after the old one was destroyed by an earthquake in 1861, the streets are made very wide, and lined with trees watered by irrigating canals running under the side walks, which are made of wood. One day we drove out to the petroleum mines, twelve miles south-west of Mendoza, and in a small circular basin in the foot hills of the Andes we found the petroleum mines, and also outcrops of coal, sulphur, silver, and copper, and a native told me that a short distance off there was a gold vein that he and his father worked and lived on for years. No doubt there is enormous mineral wealth in the Andes, but the ground has as yet not been prospected. When it is we may expect to see a rush there as in other countries.

The Future.

In the foregoing remarks I have endeavoured to show the causes which have worked against the destinies of the Argentine Republic in the past, and how these evils have one by one been removed. She has given us a pledge for her future behaviour by passing nine years without a revolution; and several questions of boundaries with her neighbours have been peacefully settled by arbitration without an appeal to arms, the Government thereby showing that they consider a peaceful policy to be not only the best, but the only one within certain limits. There are three things required for the material progress of the country—peace, immigration, and capital; the first she has, the other two she is procuring at an ever-increasing ratio under the present strong and able Government. Under these circumstances I think, without optimism, that we may look forward to a grand future for the Argentine Republic.

DISCUSSION.

Mr. John Samson said he was very familiar with the Argentine Republic through being connected with the *South American Journal*, and was continually hearing of all that took place in that country. Having collected the statistics since 1880, he could corroborate the remarks of Mr. Smythies. The development of the Argentine Republic dated from the advent of General Roca as President. Until this gentleman became President there was no stable Government. He had no doubt that General Roca would be re-elected as President. In a conversation General Roca pointed out many projects whereby in the future the country might be developed. He was certain that they would never see another revolution in the Republic, for, previously, revolutionists could ride across the country untrammelled, but now that it was fenced, all this was put a stop to. Again, they had the telegraph all over the country, the consequence being that troops could be at once sent to any place when a disturbance occurred, whereas formerly news of a rising did not reach headquarters until it

was too late to interfere. He did not consider that the competition between railways was so keen as Mr. Smythies had stated. No doubt anyone looking at the map would think that the railways were very close together, but this was not the case, and the mistake arose from the plan being drawn on a small scale. In order that English readers might understand the relative distances of places in South America and those in Europe, a map had recently been published in the *South American Journal*, and the result might be summarised as follows:—If the position of Buenos Ayres be taken as represented by Paris, then that of Rosario would be almost corresponding to that of London, Cordova to that of Liverpool, Tucuman to Inverness, Sunchales to Hull, Villa Maria to Penzance, and Mendoza to Cork. In view of such widely separated routes, it was absurd to classify the competition between railways in Great Britain with those of the Argentine Republic, especially when there are no roads in the country.

Mr. J. W. BATTEN said he twice visited the Argentine Republic, and had come back impressed with the place and its suitability for English emigration and English capital. He saw no reason why English capital should not be invested in the Argentine Republic judiciously for a great number of years to come, and he trusted that no one who had anything to do with railways in that large country would enter into the suicidal competition which the reader of the paper seemed to fear. What seemed on the map as competitive lines were in reality nothing of the sort. The whole of the country round Buenos Ayres was one large alluvial plain without a single stone. Gardening and agriculture was of the easiest possible character, as there were no trees to cut down as in Canada, and railways could be made through the country without the amount of competition which one might fancy, because on the large plains there were no roads. When the farmer had cultivated his field, he had to carry the produce to the nearest railway station, but he could not carry it beyond a certain distance. It would not pay to carry wheat beyond 40 miles, and the consequence was that a belt of 40 miles on each side of the railway was the extent of cultivation of cereals for railway traffic. They might make railways within 80 miles of each other without doing the slightest injury to either. The rapidity with which the country developed was something remarkable. In October, 1887, when he was there for the second time, he rode over the land within 35 miles of Rosario northward, and in a ride of 105 miles, though he could see the blue horizon always, he did not see five houses, and when he came to the place where the terminal station was to be put, he was astonished to find that there was not a single house to be seen; but the other day the manager of the railway wrote stating that the railway was completed, and so rapidly had the filling up taken place that the country through which he rode was now one vast plain of wheat. The fact was the Italians had followed up the navvies, and as the railway was made they cultivated the country for wheat. Leaving the country as an investment for railways, he would rather direct the attention of the Society to what was, to his mind, the most interesting thing connected with the country. The Argentine Republic manufactured nothing, but it produced an immense quantity of raw produce, and it was ready to send in exchange for English manufactures countless tons of hides, tallow, wheat, maize, and wool. All over this large area, which was 20 or 30 times larger than England or Wales, people were crying out for English manufactures, but were unable to obtain them. Some people had seen what an opening there was, and among others, Messrs. Negretti and Zambra, the opticians, who had actually gone into the trade of exporting coal, simply because the Italians had asked them to do so. Again, he had travelled out to Buenos Ayres with the agent for Pears' soap, who did good business there. This proved that if English manufacturers would send out trusty travellers, there was any amount of work to be done. This year he had sent out thirty young men to the Argentine Republic, who were earning small wages in this country on the railway, all of whom were now doing extremely well. He had just had a letter from one who was a porter on the South-Western Railway, who wrote saying that he was able, from the sixty dollars a month which he received, to bank twenty-five dollars. There were not many porters in England able to do that. No doubt, an ill-considered emigration of 1,800 Irish to Buenos Ayres met with a very sad fate on arrival, but he did not know that this fact was entirely attributable to bad management. The fact was, that an Italian ship arrived there the same morning with 2,000 emigrants, who occupied the large depôt, and when the Irishmen landed there was no place for them to go to, though he found that these people had gradually spread over the country. There was work for everyone in the Argentine Republic, at remunerative wages. There was also a large opening for girls as domestic servants and governesses, and in Rosario domestic servants received from £30 to £60 a year as wages. The idea that these girls would make good wives was one not to be lost sight of, and he knew many young women who had gone out of that country who had married well. With regard to the question of emigration, he thought the Italians had a much better plan than the English. The emigration had reached from 900 to 1,000 a day into Buenos Ayres, and it was wonderful how they spread over the country so rapidly. The fact was there were hundreds of thousands of Italians now gone into the country; they came out to Buenos Ayres with scarcely anything, though in the course of a few years they saved from £200 to £400, when they returned to Italy, and told their friends what an Eldorado the country was, the consequence being that others im-

mediately came there. Having studied the question of emigration, he considered that the Mormon system, apart from the marriage question, was simply perfect. The Mormon elder met the emigrants at New York; he did not allow them to waste their time in New York, but took them in special trains straight through to Utah city, and on their arrival there they were not sent off to any particular farm, but located for two or three months on the home farm, during which time it was ascertained what they were fitted for, and afterwards drafted to their respective work, and it was in that way the beautiful oasis in the desert was flourishing at the present moment. A similar plan ought to be applied to South America, where there were many places far more fertile than the plains of Utah.

Major CRAIGIE said he should be glad of any information with reference to the export of mutton from the Argentine Republic. In his opinion no trade had developed so rapidly during the last five years as this had. Nearly one million head of sheep had been landed on our shores from the Argentine Republic last year, and to some extent the import of mutton was now taking place from Argentine into France. Of course this was a trade which depended on various conditions for its profits, and if they could have any information as to the possible future of the trade, producers here were interested in hearing what sort of competition they had to meet. The question between New Zealand mutton exports and those of other countries resolved itself into one of price, and he presumed it did not cost more than one penny a pound to bring mutton from the River Plate to England. He noticed that reference had been made in the paper to the depreciated value of cattle, and this was attributed to the failure of the Brazilian market to absorb as much beef as formerly. He should be glad to know whether Mr. Smithies thought that it was to this they were to ascribe the new Government policy with regard to bounties on meat exports, and what effect these were producing.

Mr. R. HERBERT LAPAGE considered the Argentine Republic a wonderful country, and that there was a great future before it, though with regard to railway competition, speaking as an engineer, he thought there was nothing to fear for the present. There were no roads in the country, so that it was impossible to cart wheat for more than a few miles, and as it was so easy to make railways, no doubt many more would be made. It was impossible to make roads without stones, and there were no stones to be found in a great part of that country, therefore it was cheaper to make iron roads, which were effectually ballasted with the black soil of the plains. When he (Mr. Lapage) went out to the Argentine Republic some twenty years ago, it was impossible to make use of the lands and other resources, excepting near the cities, on account of the Indians; and even within the last fifteen years, since the Central Argentine Railway was opened, they were much troubled with Indians, but immediately General Roca came into power he grasped the situation, and in the course of a very few months drove the Indians away, and enabled capital to be securely invested. From that time the country had progressed marvellously, and the lands had increased enormously in value. There was no doubt General Roca had done wonders for the country. Up to the present very little had been accomplished in the way of irrigation, but there was no doubt water could be brought all over the country if the necessary capital were forthcoming, and thus the immense prairies could be irrigated. The soil was of an excellent kind, there being two feet of black soil all over the plains. He quite agreed with the observation in the paper with regard to alfalfa, which was excellent provender for all sorts of animals, and he had no doubt that large quantities would be grown for export. He also thought that the trade in frozen meat would rapidly improve, as animals could be purchased in that country at a very low figure, and transported at a cheap rate. No doubt additional large freezing stations would shortly be established, in which case the trade would be largely increased.

The CHAIRMAN said undoubtedly the whole question of the Argentine Confederation was one of very great importance, and more particularly because it could hardly be considered by itself without looking at Uruguay and Paraguay, which had similar natural advantages, and which were likewise in a condition of progress and development. He was in hopes that in a paper on such a subject they would have had some reference to the part which English enterprise had played in the development of the country. Our good friends in the Republic were very apt to entertain the notion that the present prosperity was largely due to themselves, and that it was dependent upon their own exertions, but he thought they had heard enough from Mr. Batten to see that there must be some other influence besides Argentine influence at work in producing these results. Mr. Batten very modestly referred to his own position in connection with Argentine railways, but he might have gone further back and recollected the knowledge he had of English railways as one of the few men now living who were concerned in their early inception. It was mainly by English influence and intelligence that the development of the Republic had taken place. Even with regard to railways, it had been impossible to make them without the means of English invention and English enterprise, so likewise the inventions of Bessemer and Siemens had provided the steamships which had given cheap freights for the produce from Argentine regions. There had been a suggestion that there was a want of enterprise on the part of English manufacturers, but it certainly did not strike him so, for he knew there had been a special development of agricultural machinery for countries like the Argentine Republic, and these machines had played a great part in the advancement and development of

the country. Some reduction must be made in the comparison between Argentine and English agriculture. Surely it would strike anyone that it would be an extraordinary thing that firms such as Clayton and Shuttleworth, and Ransome and Sims, could not provide machinery for England when they could, by their own energy, provide it for such a distant region as the River Plate. The River Plate consisted of large prairies of alluvial land, with a black soil two feet deep, and on such flat plain any kind of agricultural machinery could be worked, but on a rolling land like our own in this country very different machinery was required. In the eastern provinces of Canada you had rough land, but in Manitoba the soil was identically the same kind as in the River Plate. It was necessary to bear all these considerations in mind in attempting comparisons between one country and another. They had heard of what the Italian labourer would do in the River Plate, and it was suggested that the English agricultural labourer had not equal industry, but it should not be forgotten that in Canada the English labourer had to do the same kind of work as the Italians in the River Plate, and he did it. There were numerous circumstances which made the English labourer less willing to emigrate to the Plate than the Italian. The Englishman could go to English-speaking countries in Canada, South Africa, and Australia. The Italian labourer was not in such a good position as the English labourer, and the consequence was he was much more willing to change his position. The English labourer knew perfectly well that if he chose he could have 160 acres of freehold land in Canada and be taken to it, but he knew that he and his wife would have to work morning, noon, and night, and knowing all these things, for his brothers and brothers-in-law in Canada were men of property and substance, he preferred his condition in England, with such comforts as he had, to the greater share of work which must fall upon him if he emigrated. Mr. Batten had opened up a subject of considerable interest with regard to the method in which it was desirable that emigrants should be looked after in the River Plate. In Canada, considerable help was afforded by the St. George's Societies, and in each large town there was a St. George's Society, which assisted emigrants upon their arrival. If there were no means of employment for the emigrant at one place he was forwarded on by the society to another place, until at last he was placed in a situation where he might earn his livelihood and gain a competency. It would be well worth Mr. Batten's while to think a little about these societies which were to be found all over the United States and Canada, but which were not to be found in other places. Mr. Samson had given a key to the condition of the Argentine Republic. The Argentine people were too much in the habit of calling upon the English people to depend upon the great resources of the country, and to claim elements of stability which really did not exist in other communities in the world; they were asked to believe that Argentine loans would always be paid, and that Argentine stocks would always have high prices, and that the country would be still further developed in future; but the real consideration with regard all these South American countries was not the land, not the number of acres, or number of head of cattle or sheep, but it was the people of the country and more particularly the man at the head of affairs. From the time General Roca became President, revolutions had ceased, but it was by no means so easy to assume that they would always have a succession of such men at the head of affairs in these countiies, and in their absence they had insurrections, revolutions, civil wars, &c., financial disasters and repudiations. Mr. Smythies took a more roseate view of the currency question than many people were disposed to do. There must be something wrong in the large development of paper currency regardless of circumstances and economical laws, which had resulted in the enormous difference between the gold currency and the paper currency, and, therefore, they must keep their eyes open with regard to the proceedings of the statesmen and governors. There was another circumstance to be borne in mind, and that was this, that the Provincial Governments were coming in as borrowers, and if any difficulty occurred with the Provincial Governments, the people who suffered would have no real remedy; they could not appeal to the Foreign Office, because there were no diplomatic relations between a foreign Government and a provincial Government. Indeed most of the provincial Governments that were borrowing took care that there should be no relations between the foreign consuls and their own local Governments. He did not say this in diminution or depreciation of the resources of these great countries, but in order that they might be sufficiently on their guard for their own benefit and advantage. The people in the River Plate were too apt to think that they had attained the period of all sufficiency when they were able to compete with the great Governments of the world, and were particularly disposed to get rid of the aid of their English friends, and the result was that they were not contented to be so indulgent as they formerly were to English capitalists, but had begun to press upon them with vexatious impositions. They believed they could get all they wanted from French, Germans, and Americans, but it would be a very long time before they were able to do without our assistance. Lately they had been borrowing from the French, but everyone knew what a disastrous failure had lately occurred in Paris, and how unsafe it was to depend on that market. The crisis there had been already accompanied by the stoppage of public works and railways in many parts of the world. In conclusion, he proposed a hearty vote of thanks to Mr. Smythies for his interesting paper, which was carried unanimously.

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FRIDAY, APRIL 26, 1889.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

Proceedings of the Society.

APPLIED ART SECTION.

Tuesday, April 9, 1889: Edward C. Robins, F.S.A., Member of Council, in the chair.

The paper read was—

ARCHITECTURE IN ITS RELATION TO LANDSCAPE.

By H. H. Statham.

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It may perhaps be thought that some excuse is required for introducing the subject of Architecture and Landscape into the Applied Art Section of this Society, and that it is not exactly evident where the "Applied Art" comes in. My view of it is this, that just as in decorative art there is, in regard to detail, a meeting-ground between nature and artificial form, a point at which, on the one hand, natural detail has been so far artificialised, or conventionalised (as the usual term is) as to make it harmonise with man's artificial design and manufacture, while on the other hand purely artificial details may be arranged so as to blend with the design derived from natural forms: so, if we compare nature as a whole, apart from detail, with architecture, which is the blending of all detail in the one great and master decorative art, there comes in, on a larger scale, the same question—how are these two elements, the artificial and the natural, to be blended so that each shall assist the other—that the architecture shall add a new beauty and expression to the landscape, and the landscape shall not detract from or interfere with the effect of the architecture. In other words, if we wish to keep in mind the nomenclature proper to this Section, how are we to deal with architecture as "applied" to landscape?

I consider the subject, however, as including town architecture as well as country architecture. There is town scenery as well as country scenery. After we have considered the design of a single building as a whole, we next come to the consideration of its grouping with other buildings, and their mutual effect on each other. Then we generalise further, withdrawing our attention from special buildings to consider the whole scenic effect produced by a group, by a square, and even in certain cases by a whole town seen comprehensively from a distant standpoint. Thus town architecture, viewed *en masse*, becomes in itself a form of landscape effect, and I need hardly remind you that one of the most accomplished water-colour artists of the day has for some years devoted his chief efforts to the painting of what may be called London scenery, with the result that his works are generally among the most interesting and romantic in effect among the "landscapes" of any exhibition in which they may be found. From this formation of artificial landscape in towns we pass to the closer connection of architecture with natural scenery in the case of buildings placed in the open country. Here again we proceed from the more formal and artificial architecture, which contrasts with the landscape, to that more picturesque (as it is called) and less artificial architecture which seems to partake itself of the character of nature, and to become part of the scenery. This last is more especially the case with old buildings, and those of an unpretentious character; village churches and cottages, which in the course of years or generations have been slowly harmonised, by the colouring of time, into unity with the landscape. But when new building is to be done on a large scale and with ample means, the transition from architecture to nature may be carried out, through the treatment of the grounds and surroundings, in a very complete manner: connecting the house by architectural terraces and steps, first with a formally designed garden, in itself more or less architectural in its symmetrical character, then with plantations not symmetrical, like the garden, in detail, but symmetrical in the general arrangement of their masses as in reference to the more ornamental grounds, while further out they gradually die away into the natural wildness of the surrounding scenery. A familiar example of an attempt

at this blending of the house with the landscape is Hampton Court, with its classical garden front, its symmetrically arranged flower garden and lawns and radiating walks, and its canal and avenue in the Home Park: but it is only partially and incompletely carried out, and on one side the Thames puts an abrupt stop to the composition. In the few instances where this kind of scenic design on a great scale can be carried out, the style of architecture of the house itself may be almost anything you please, provided it is good in itself, since the ground can be manipulated to suit it. But except in these few cases where great resources are at command, such as are seldom realised except in the case of a few royal palaces here and there, the architectural style of the building itself, as as well its position, should be considered in reference to the landscape; the consideration of style being mainly a matter of sentiment, that of position a matter of what painters call composition. The practical considerations in selecting a site for a house are, of course, intentionally left out of consideration here; they are most important, but do not come into this subject; it is only necessary to keep behind all considerations as to the picturesque character of a site, the mental reservation—provided always that the sanitary conditions are satisfactory.

The subject is a difficult one to illustrate adequately. I propose here to offer a few general suggestions as to the treatment of town and country architecture, partly illustrated by some sketches on the walls, and then to pass in review a series of photographs from actual scenes, which will, to a certain extent, illustrate these suggestions, though necessarily in a somewhat incomplete manner, inasmuch as photographers do not select their subjects or their points of view with any such intention.

To take first the architectural effects of cities. There are two great distinctions between ancient and modern cities, architecturally considered. First, the ancient practice of building a city within definitely marked boundary walls has been discontinued, and the city, as such, has lost its unity and defined character; it is now no more than a tract of land irregularly covered with buildings. Consequently the chance of actually designing a city for effect, planning it as a whole from the beginning, is never to be thought of now: Wren had a chance after the burning of London, but the authorities were too much for him. There is no doubt, however, that the deliberate laying out of a large city as an architectural design might result in some splendid architectural effects. I may take as an instance Liverpool, which has climbed and extended itself irregularly and piecemeal along the floor and up the sides of a theatre of gently sloping hills, with the river flowing across the chord of the arc. If this city could be begun again, and built in semicircular terraces height above height up the sides of the "theatre," it would be, or could be made, one of the most magnificent architectural spectacles from the river that has ever been seen. It is probable that some effect of this kind was realised in such cities as ancient Babylon; but such effects belong essentially to despotism. In a modern town there are too many independent interests to be consulted, and such unity of design is impossible. Bath, however, may be named as an example of a city in which a considerable portion was planned and laid out for effect under the direction of one architect, Wood, and with the result that it is one of the most dignified and stately cities of second-rate dimensions; owing of course something to its beautiful site. In Edinburgh it may be said that the site has done everything and the architects next to nothing; there are few really good buildings there, and they do not much affect the general aspect of the city; the advantages of site, for picturesque effect, being such that the worst architecture could hardly have spoiled it, though the finest might add something to it. The other modern distinction is that whereas evidently the ancient routes of streets were mostly determined either by the configuration of the site or by existing landmarks of property, in modern days we lay out the new streets according to deliberate forethought. We cannot lay out a whole town according to a set plan, but we can and do lay out its new streets deliberately, and one result of this is that whereas the old streets had generally curved lines, the modern ones are nearly all straight; a matter which has given rise to much criticism of late. It has been rather too hastily assumed that all streets look better if curved or winding. All streets which are composed, as the great majority are, of buildings of varying height and design, are better so, no doubt: but where it is an object to produce an effect of palatial stateliness, streets running in a straight line, and with buildings symmetrically designed on a preconceived scheme, have their value in the effects

of a town. It is a treatment monotonous, no doubt, for general use, as Harley-street and Cromwell-road testify too well, but when used in moderation, and in connection with buildings of a sumptuous and stately character (for that is imperative) it is capable of very fine effect. In streets of irregular buildings it is argued (by utilitarian people) that there would be something absurd in deliberately laying ont a new street on irregular lines for the sake of effect. So long as it is not done to the extent of injuring the convenience of the buildings, I do not see that it is more absurd than laying out garden walks in curves for effect, which is done every day. The object of the garden walks is a practical one—they are for people to get about from one part to another; the streets are only the same thing on a larger scale: the picturesque and the practical may be deliberately provided for in the one case as well as in the other. Shaftesbury Avenue has been laid out in curves, and if the new buildings flanking it were not unfortunately (so far) such poor specimens, it would be in the way to be a picturesque street, with no harm to any one that I know of. It will at any rate be impossible to make it as soul-deadening as Victoria-street or Cromwell-road.

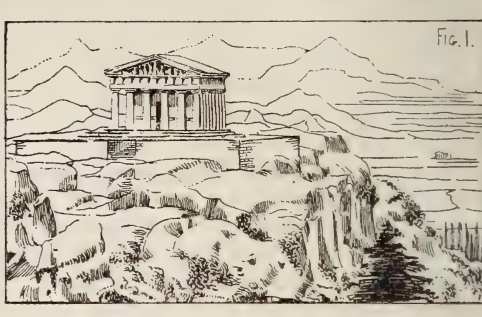
The question of straight or crooked depends a little on what you have got to see at the end of your street. If you have a great building or monument to close a straight vista, then you had better have the vista. This subject of centralising buildings and streets and squares on an axis, so as to seem part of a thought-out design, is made a good deal of in France, and much neglected here. It has even been urged, by some of those who think most about the subject, that this centralising is a vanity and a fallacy. It is said that St. Paul's, for instance, has a finer effect from standing askew to the top of Ludgate-hill, than it would have if it faced Ludgate - hill centrally. I am inclined to think so too, but that is because Ludgate-hill is only — Ludgate-hill. If it were a broad avenue of stately columnar buildings of similar type to St. Paul's architecture, perhaps combined with an avenue of trees, I think you would want St. Paul's to face it centrally. Take the case of St. Peter's, with its artificially planned colonnades and fountains symmetrically arranged in front of the façade; you could not possibly propose in that case to set the building obliquely to the *place* in front of it. But as, in the case of St. Paul's, we have only a narrow street of miscellaneous shops leading to it, that is *infra dig.*, and it was better the cathedral should ignore it. The one is the architectural effect, the other the picturesque. I do not know that the one is better than the other, but they are different, and you cannot have both together; you must have one or the other. In London we are always just missing the architectural treatment, by carelessness or blundering, without getting the picturesque one. Thus we put the Albert Memorial just nearly enough on the axis of the Albert Hall to look as if it was meant to be centralised but had been set out wrong. We have made Constitution-hill a straight vista with a monumental arch at the end, as if it formed a piece of symmetrical architectural planning, and when we come out at the arch we find it cuts into the shoulder of a curve and leads nowhere. Now I think that in the most important squares and streets of a large city, especially of a capital, symmetrical laying out and centralising of the principal streets and open spaces and buildings is quite in place; it is an element of stateliness which is proper to such a situation, and the importance and value of which has been much underrated by modern critics.

Of course one cannot overlook, in this connection, the curious fact of the total disregard of symmetry which the Athenians showed in the placing of their very symmetrical buildings in and about the Acropolis, even building the small Niké Temple by the gate slightly crooked to the gate. This proves that they were indifferent as to symmetrical relations of their buildings, in this case at least, and that they did not regard the Acropolis architecture as a whole, but as so many independent buildings placed where they were most convenient. I do not think that there was a calculated effort, on principle, to avoid symmetry in placing the temples. They were built at different times and for different objects, and were not thought of in connection with each other.

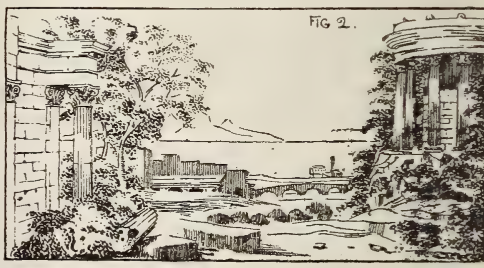
The combination of foliage with architecture in cities is a source of beautiful effect, and I will call attention to one or two examples later on of the increased effect given to city buildings by an admixture of foliage in the scene. I may refer again to Edinburgh in this connection, and notice the fine effect of the high buildings on the Old Town side, as seen from Princes-street. In London we may remark the picturesque effect of the Foreign-offices as seen from the suspension bridge over St. James's-park water, rising over the mass of

trees, with the water in the foreground: a London picture which would be worth painting: I never saw a picture of it yet. It is worth while, also, to keep an eye on vistas into the surrounding country from the city. At the end of one of the longest, straightest, and dullest streets in London, for instance, which the cab-drivers call "Gow-er"-street, but which is properly pronounced *Gore*-street, there is to be seen, on a certain number of days in the year, more or less (according to the state of the London atmosphere), a vision of a distant hill, like the Delectable Mountains in the "Pilgrim's Progress," filling up the space between the two rows of houses with its faint distant green and purplish tones. This is Hampstead-hill, which (though few people in London know it) stands at its highest point just on the line of Gower-street, and sends a glimmer of nature down the street. I should be sorry indeed to see even the best new building block out that little incident. Of similar value, in a rather different way, would be the opening a view of the Mall and the trees into Charing-cross, if Commissioners of Works ever allow us to have it done. Before quitting this question of architectural landscape in towns, let me name one splendid effect in London, also little known, viz., the view of the Victoria Tower from what is called the Little Cloister at Westminster. As an architectural picture this view of the great tower, seen looking up from the confined little cloister yard with its prim arcade and railings for the foreground, is really sublime, and if Mr. Herbert Marshall's attention were directed to it, we might hope to see it illustrated in a manner worthy of the occasion.

Coming now to the country, and the combination of architecture with natural scenery, it has been said that this may be considered under two heads, the character or sentiment of the building as compared with that of the landscape, and its position as a matter of composition. The former relation is one exceedingly difficult to define or to reason about. The harmony of a building with the landscape depends on so many considerations of detail and, even of association, that it seems almost impossible to frame any principle which shall meet or explain all cases: it is a matter to be felt rather than reasoned about. It has been said that Greek architecture is specially unsuited to wild and rocky sites, yet the Greeks planted their masterpieces of architecture on the Acropolis rock, and there is the sketch of Cockerell's restoration of the Temple of Jupiter at Ægina (Fig. 1), on a platform on a rocky site, and not looking I think out of keeping with its position, though it might look so without the platform; I have introduced that in order to connect it with the rocky ground. The Doric temples of Pæstum are on a level plain: and



Linton's large painting of them, No. 1029 in the National Gallery, rather goes to prove that they are not very well adapted for pictorial treatment, at all events, on such a site. On the other hand both Claude and Gaspar Poussin, and other landscape painters of that school, love to combine their classic ruins or temples with foliage and with quiet and pastoral landscapes, as shown in some of the sketches in the *Liber Veritatis* (Fig. 2); and the two



elements seem to harmonise beautifully. It must be observed, however, that Claude never uses the sterner forms of Doric architecture, of which in fact he knew nothing: he painted the remains of Roman classic architecture as he saw them combined with Italian scenery. Turner, in such paintings as "Dido building Carthage," and others where a quasi-classic architecture is introduced (quite an anachronism by the way, as he introduces Italian Renaissance architecture into very ancient classic legend), is fond of the rounded masses of foliage of the stone pine, in contrast with the straight lines of his architecture. On the whole it may perhaps be said that Doric architecture harmonises best with wild and rocky scenery, and that the lighter and more graceful forms of Greek architecture har-

monise best with more pastoral and wooded scenery: though there here rises up in my memory Mr. Poynter's picture of the "Visit to Æsculapius," with the great white Doric columns shimmering through a mass of foliage; but that we may say is detail—neither the whole building nor the whole landscape are seen. There is another sketch from the *Liber Veritatis*, in which Claude has placed a small circular temple on the very top of a rock (Fig. 3), and placed

FIG. 3

his castellated architecture at the base. Here the castle seems to defend the entrance to the town, and the temple is placed safely aloft; but I should like it better if the hill were rounded and clothed in trees rather than a bare rock. I have made a sketch (Fig. 4), copying Claude's composition

FIG. 4.

precisely, but reversing the style of the buildings, and placing the castle at the top of the rock, to try the effect; it gives an absolutely different sentiment to the view at once, and, at all events, illustrates the important effect which the architecture introduced has upon the expression of a landscape. In other drawings Claude adopts the system of placing the castellated buildings on the high and not on the low ground; and these sketches illustrate another habit of his, that of introducing a castle or tower to give greater effect, by contrast, to his graceful classic architecture; a hint as to the value of plain spaces in a building in giving emphasis to the more decorative portion.

Generally speaking I think we may conclude, in spite of occasional exceptions, that a stern and severe landscape demands a massive and severe style of architecture, a quieter and more wooded landscape, a graceful and delicate style of architecture; and mountainous ground and a lofty position demand powerful buildings, of comparatively horizontal character, while a low level landscape permits and demands buildings of a less severe style, and with lofty vertical features to contrast with the lines of the landscape. A spire on a hill is completely out of place: there is an instinctive feeling of insecurity; on a low level it is the expression of an attempt to rise, an aspiration, which on the height is uncalled for. A characteristic illustration of this is shown in a view which I found in an old sketch-book in the Institute of Architects' Library (Fig. 5), where

FIG. 5.

the remains of the castle are seen on the hill, the village with its trees and church spire clustering at the base. A square Scotch castle rising from a level lawn, like the sketch of Udny Castle (Fig. 6: it is

FIG. 6 6a

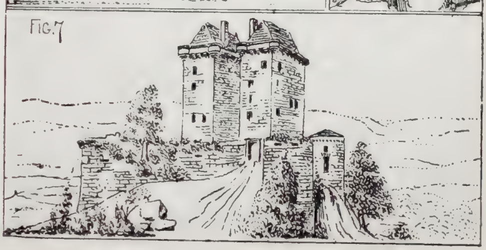
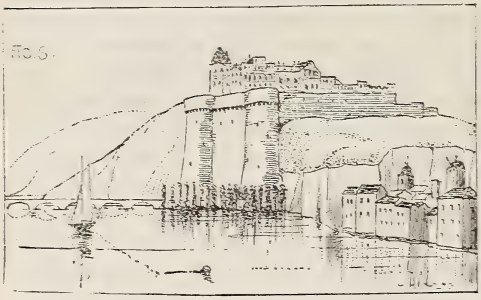


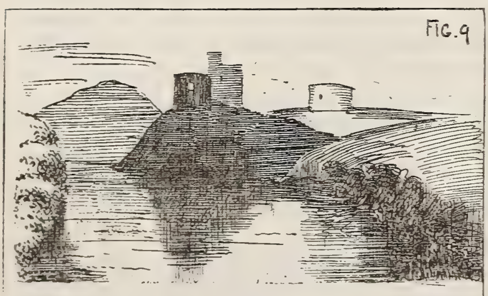
FIG. 7

all built up with modern additions now), looks curiously out of place. Where, as at 6A, or as at Borthwick (Fig. 7), the castle is led up to by a precipitous ascent, its stern rock-like machicolated towers seem in keeping with their position; and the full wildness and sternness is reached when a castle is, as it were toothed into crags and precipices, so that you can hardly say where the rock ends and the building commences. A remarkable example of castellated effect of a somewhat different kind is shown (Fig. 8) in



Turner's sketch of the Château d'Amboise (*Liber Studiorum*) where the great bastions founded on the lower level seem to stand on guard beneath the habitable château on the top.

A rounded and wooded hill, equally with a bare and precipitous one, seems to require a repose and solidity of form in any buildings placed upon its summit. Turner repeatedly shows his predilection for this effect, as in the sketch here from his "Kilgarron Castle" (Fig. 9).



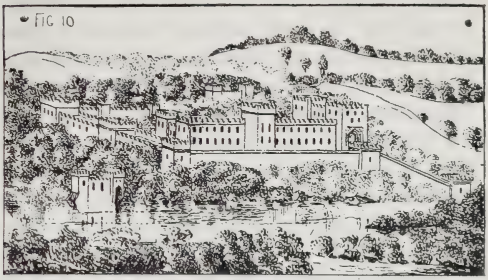
Every one I think will agree that if, for the compact and square-proportioned masses of castle, you were to substitute a thin and spire-like building, the feeling of the whole composition would be destroyed. A similar effect is shown in the pile of square-lined buildings of Cintra, with a dome as the only prominent feature, clustered on the top of a wooded hill. It may be observed that this effect of building of a rather solid and horizontal character, rising above undulating masses of foliage, is nearly always pleasing; one or two other examples will be shown further on; but on the other hand Gothic architecture, at all events in its more ornate and be-spired and be-pinnacled examples, is out of place among trees and woods, in spite of various rhapsodies of the poets on the subject. For combination with foliage we want level lines and broad masses, which is the reason classic and Italian architecture generally goes well with a wooded landscape; Gothic architecture of the later period is the architecture of towns rather than of country; its multitudinous detail, which in a city supplies an element of richness and variety of detail, in the country only seems attempting to compete with the infinite detail of nature; and its varied skyline does not present sufficient contrast with the equally varied skyline or silhouette presented by trees. The early Cistercian monastery churches, nearly always placed in wooded valleys, were of a broad and simple type of architecture with little decorative detail, and their expression of repose, and the broad simplicity of their architectural design, harmonise admirably with their situation. Such Gothic as Henry VII.s' Chapel, on the other hand, is essentially city architecture. So also are the French cathedrals of the middle Gothic period, with their forests of stone scaffolding in the shape of flying buttresses; in an open country they would be intrusive and pretentious; in a city, with houses piled up all round their base, they seem the natural expression of the crowded and intricate life of the city. Our simpler English Gothic has in many of its examples an expression of repose and reserve which fits it for the very different position which most English cathedrals occupy, in the midst of an enclosed lawn or "close," instead of being packed up amid heaps of house architecture piled in irregular masses almost against their very walls, as is often in the case with continental cathedrals. I remember being much struck, when I first saw Salisbury Cathedral, with the remarkable fitness of the building to its site; its graceful and elegant design, all complete in nearly the same period of architecture, and therefore with a unity of style and expression which most of our cathedrals have not, rising from a base of level lawn giving admirable contrast and effect to the vertical and pyramidal lines of the building. Hence I was much interested to find, only a few days ago, in the charming letters of

Motley the historian, which have just been published, a record of a similar impression about Salisbury Cathedral, which is worth quotation here:—

"This was the first specimen of English Gothic I was to see, and as I walked thither my head was full of the Continental Gothic, which as yet was all I knew. I thought of the Cathedral of Cologne, of Vienna, of Rouen, of strange unfinished, unfinishable buildings, built according to no plan, or rather according to a dozen different ones, and rising helter-skelter from the midst of a multitude of old, sharp-gabled, red-tiled, ten-storey houses, all looking as if built in the time of the Crusaders. The idea of a Gothic cathedral was associated in my mind with hundreds of tumble-down hovels, booths and shops, mixed grotesquely here and there with a magnificent palace of half a dozen centuries * * * so that on the whole, when I came to look on Salisbury Cathedral, I was most ridiculously half disappointed.

"It was my own fault or my own stupidity. The church is of beautiful proportions, of the most beautiful (at any rate the most regular) of the Gothic styles (namely, the Early English), is built of a fine coloured stone, which looks as fresh as if of yesterday, and with its light and graceful and very high spire, its long lancet-headed windows, its massive walls and stately buttresses, is certainly one of the finest cathedrals I know. Influenced by the associations I have mentioned, I thought the whole scene at first too tidy, too notable, too house-wifish; but, as I said before, this was only my own dulness; on second thoughts I acknowledged to myself that filth and poverty and ugliness were not necessary concomitants of a cathedral, and I confessed that I had rarely seen a more lovely picture than this same church presents. The scene is so softly and sweetly English. The stately and graceful cathedral with its green and smooth shaven lawn in front, the surrounding elm-trees in their magnificently massive foliage; the tidy cottages half covered with honeysuckles and rose-bushes, the hawthorn hedges, and the green meadows with their sleek cattle (to say nothing of the macadamised turnpike and the new hotel), altogether make up a scene purely and exclusively English, and perhaps, after all as pleasing a one as you can find anywhere." *Motley's Correspondence*, vol. i., pages 59-60.

It is worth note that Repton, who had such an immense reputation as a landscape gardener in the early part of this century, and whose wholesale method of "treating" ancient mansions and parks, so as to get new effects out of them, is rather satirically referred to in Jane Austen's best novel,* evidently had a strong impression as to the fine effect of broad solid masses of building, rising out of equally broad but undulating masses of trees. Two of his sketches for effects of this kind are given; one is Bayham Abbey (Fig. 10), the other a composition: the idea is the same in both cases—to have square battlemented buildings rising from among undulating masses of trees. Repton may have done



many foolish things—probably did—but in his liking for this particular effect he has, at any rate, the sanction of Milton—

> "Straight mine eye hath caught new pleasures,
> Whilst the landscape round it measures;
> * * * *
> Towers and battlements it sees,
> Bosomed high in tufted trees"—

an expression which exactly gives Repton's pet ideal.

What was true about Salisbury and its level lawns is true about spire architecture and level country on a more extended scale. Spires, as before observed, are out of place on a hill, and they are not very effective beneath a hill, and this seems to have been tacitly felt by spire-builders. In mountainous landscapes we generally find that spires, if introduced, are mere little picturesque timber and shingle affairs, toy spires; not work of a monumental type. It is on an expanse of flat country that a spire, or a tall tower with a spire or lantern termination, enjoys its true honours. Lincolnshire, most of which is as flat as a plate, is a remarkable district in exemplifying this. There the spires seem to vie with each other in height and slenderness of proportion, as if there was a game of brag between the builders (as there very likely was) whose spire should rise highest and be seen farthest. On such a coast "Boston stump," as it is irreverently called, was a thing worth building; its whole height can tell for many miles inward and seaward, in a district where the land is as flat as the sea; on a higher and more undulating coast half its value would have been lost. Lincoln Cathedral, on the other hand, standing on the top of the only eminence for many miles round, requires no

* "Mansfield Park:" chapter vi.

spires; it may have been intended to have spires, but it is much better suited to its site without them, and perhaps it is the lofty and exposed situation which prevented their being carried out, nature in this case imposing her own law of æsthetic. Peterborough Cathedral, which stands low in a level country, suffers very much for want of a central spire, and I have always regretted that the Archbishop of Canterbury's brilliant and cleverly-worded judgment on the Peterborough restoration dispute should have summed-up by dismissing Mr. Pearson's proposed new spire with costs: the spire would have been an effective and legitimate completion to the building and a great addition to the landscape. As it is, Peterborough Cathedral has no means of asserting itself in the landscape; you have to look for it, and have some difficulty in finding it.

The combination of water with architecture is often a source of beautiful effect; in fact there is such an enchantment in the reflection of buildings in calm water that it may almost be said that the poorest and most commonplace architecture will have a charm under such circumstances. That is half the secret of the extraordinary charm of Venice; it is not only the peculiar picturesqueness and richness of her architecture, but the having it framed amid the glancing lights and reflections of water, one effect of which, sometimes overlooked, is in the double lighting of the architecture, from above and below. This combination of architecture with still water gives a great added beauty to many of the French Renaissance châteaux, with their moats and often with a partially encircling river or canal reflecting their turrets; also, it need hardly be added, to many of the Dutch country houses and towns. In a town, unfortunately, there is always a certain difficulty in keeping artificial water clean and wholesome; but if that were surmounted (and it can be with a little care and cost), I have often thought something might be attempted in this way to give new brightness and variety of effect in cities. An audacious proposition was made a few years ago, to make the whole of Trafalgar-square, between the roadways, a basin of water. One would wish to see a better National Gallery façade to reflect in it; but with a really fine façade there the effect would be splendid if properly done. However no doubt this is, as people say in another place, "outside the region of practical politics." In regard to the combination of architecture with water in the shape of either lake scenery or on a seaside site, the two conditions seem to demand a special and very different treatment. A lake is usually surrounded by high hills, in relation with which vertical features are out of place or are thrown away; and, except in violent weather, a lake secluded by the hills round the bases of which it is formed suggests an idea of repose of effect; and both this feeling and the level expanse of the lake water, seem to me to suggest an idea of level building, of repose combined with grace of structure. A building close on the sea, on the other hand, should above all things suggest the idea of massiveness and stability: rock-like surfaces of wall against which the salt-laden sea wind may beat in vain. Longfellow has summed up in an admirable stanza the expression of the stability of a lighthouse against the storm:—

> "The startled waves leap over it; the storm
> Smites it with all the scourges of the rain,
> And steadily against its solid form
> Press the great shoulders of the hurricane."

In the two last lines you almost feel the tremor of the building under the pressure of the wind. A lighthouse is a special building for a specially exposed site, of course: but what I mean to suggest is that seaside architecture should have something of the lighthouse character about it, it should seem like a bastion against the winds and waves. Some of the new school of American architects have realised this exceedingly well in designs for sea-side houses. It is an odd contrast to this theory, certainly, that as a rule what are called watering-places, in England especially, are more gimcrack in their architecture than any other class of towns: probably because they are largely composed of lodging-houses run up for commercial reasons, and occupied by no permanent tenants. In the old unsophisticated portions of seaside villages it is curious what a tendency the cottages and smaller houses have to assume a character that reminds one vaguely of boats, so that in railway travelling I have fancied I could tell when we were nearing the sea by this boat-like character of the cottages, with a much larger employment of wood, especially of tarred wood, overlapping like the planking of a clinker-built boat. It is quite certain that a cottage in the neighbourhood of the sea will usually have a totally different expression and character from that of a cottage in an inland agricultural district.

In regard to composition in the placing of architecture in landscape, this cannot of

course be carried out with the same choice and decision as in a picture, because we cannot in a real landscape impose any special point of view on the spectator; as Shenstone the poet discovered when he created an artificial distance in front of his house. This was done by planting the trees at the margin of an open glade in lines approaching each other so as to create a false perspective; a break was made in the line of trees halfway, by a recess on each side of the glade, on the further side of which trees were planted of a much more slight and delicate character, and a dwarf summer-house filled up the end of the vista, painted in delicate and subdued tones to look distant. The Nemesis that overtook Shenstone was that the Lytteltons, who had the adjoining estate of Hagley, entertained their visitors by bringing them to the boundary to look at Shenstone's perspective from the small end. We may, however, consider our buildings in regard to their effect on the landscape to some extent, without sinking into this kind of bathos. It is of some interest to see how painters like to have buildings placed in their landscape, and some examples in the National Gallery and elsewhere are suggestive in this way. I may call attention first to two sketches (Figs. 11, 12)


FIG. 11.

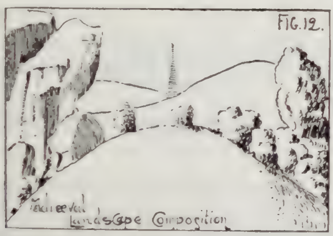


FIG. 12.

which are taken from Mediæval illuminated MSS., the only two instances I could find, in turning over many examples, of direct attempt at landscape effect in work of this type. In the smaller one the care with which the spire is planted just at the junction of two slopes of hill is to be noticed. The earlier Italian painters are delightfully naïve sometimes in the way in which they arrange these things: for instance in Pinturicchio's series of the "Story of Griselda," in one of which (No. 912 National Gallery) a long wooded hill which runs across the picture is abruptly cut off on each side and a trench left in the middle, to give room to place a triumphal arch on the lower level in the centre of the picture. Turner is fond of having a building as a light object at the foot of a dark hill, as in sketches shown from two of his compositions, and the same composition is seen in Stanfield's "Como" (Fig. 13), No. 406 in the National Gallery. Turner


FIG. 13.

values a bridge very much as a level line in the midst of a landscape, contrasting and giving value to the undulating lines of the country, as seen in his well-known picture "Crossing the Brook" (497 National Gallery), and his "Apuleia," 495 in the same collection, in which a series of nearly level lines are maintained across the picture, the bridge forming the most decisive one, which are stopped by a vertical mass of trees on the right. In Stark's "Valley of the Yare" (1204 in National Gallery) the opposite expedient is seen, the landscape alone forming the level line, the building (a church tower) the vertical one. An extended mass of building on a high platform is an effect which takes Turner's eye, as seen in his views of Blenheim and Powis Castle; and a precisely similar use is made of this effect in the remarkable landscape (considering its period) in Gian Bellini's "Christ's Agony in the Garden" (No. 726 National Gallery), where on the left a long mass of buildings on an elevated table land is shown, bright against a mass of dark rain-clouds. In Ruysdael's picture No. 990 in the Wynn Ellis collection at the National Gallery, you can see the value which a painter attaches to towers in a level landscape, where these towers at various distances serve both to contrast with the level lines

of the landscape and to mark the successive grades of distance, giving scale to the landscape. Claude employs his castles in the same way, as in the sketch shown from the *Liber Veritatis* (Fig. 14), where you have a castle

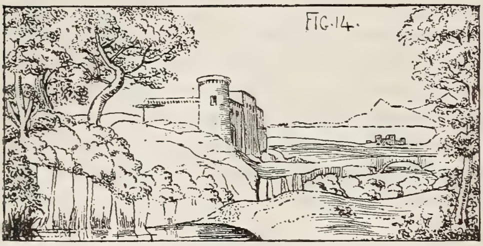


FIG. 14.

near the foreground and a nearly similar one in the middle distance, which serves to assist the expression of distance, by comparison with the scale of that in the foreground. Turner too likes to have spires as single vertical objects cutting through the lines of his landscape, as in his views of Salisbury and Honfleur. In hilly country, the opposition of level lines of building cut across by oblique lines of ground is an effect that arises naturally out of the circumstances, and which nearly always produces a pleasing effect. An example of it is the sketch from Turner's "Greville," a level plain over most of the picture, a slope of hills on the left, and the buildings seated on the hill repeating the level line of the plain. A more marked example of this contrast of horizontal architecture with sloping lines of ground is shown in Percier and Fontaine's illustration of the Villa Madama with its rigid classic lines and its level platform in front, and the slope of the hill cutting against it behind; although I doubt if this is in accordance with the actual facts. The same architectural illustrators shows the effect of straight-lined classic architecture backed by the undulating lines of a hilly country in their illustration of Villa Albani; and in that of Villa Caprarola we have the stateliness and square proportion of the classic building emphasised by contrast with the irregular piles of *roba di Roma* below. The effect of the sloping lines of landscape seen between a classic arcade in the foreground is also to be noted in one of Pinturicchio's "Griselda" series before referred to, the one called "The Restoration" (No. 914 in the National Gallery). A curious composition from a collection of sketches of Richard Wilson's (Fig. 15) shows apparently an attempt to compose buildings and hills so that the one should repeat or echo the line of the other. As an example of fortunate composition of house and landscape in an actual scene I give the view sketched in Fig. 16, where an ordinary country house has been placed at the exact point where the outline of the landscape seems to require it. In Fig. 17, the same scene with the house put back from the end to the middle of the high ridge of land, it will be seen how completely the picture is spoiled by the alteration.

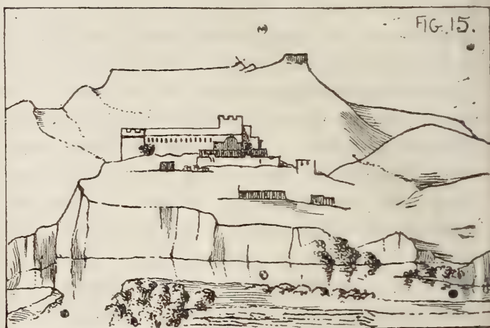


FIG. 15.

When there is more than one lofty building brought into the scene, a fine effect will often be realised by getting one in sunshine and the other in the shadow. I have seen this often splendidly realised with the two towers of the Houses of Parliament, one of them sparkling in the sun, the other frowning under the shadow of a cloud. That is one of the happy

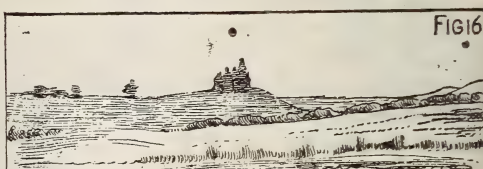


FIG 16


FIG. 17

results obtained by Barry's true architectural instinct in placing his two towers at opposite extremities of the building, (thus indicating the extent of the building,) while at the same time each tower exercises its own independent architectural expression. To put two such towers close together would be to lose half their architectural value. Turner was also observant of this effect, as shown in many of his works—in his powerful *Liber Studiorum*

sketch of the Martello Towers near Hastings, in his sketch of Greenwich from the same collection, one cupola in sunshine and the other in shadow; in his "Coventry" with two spires in sunshine and shadow in like manner, and a third sparkling from behind a rain-cloud. The dazzling intensity with which a tower of any kind will sometimes show when caught by the sun and backed by a deep cloud, especially in thundery weather, is extraordinary; no mere painting can give anything strong enough for it. I remember a sea-coast effect once of this kind, with a white lighthouse standing out against a thunder-cloud, which was so striking that though it is at least twenty years ago, the impression is as fresh on my mind as if it were yesterday. These brilliant atmospheric effects on buildings are of rare occurrence, certainly; they depend on a concurrence of circumstances; but they show what part a building may play in a moment of extraordinarily powerful landscape effect.

Among instances of special effect produced by buildings in landscape is one of which Turner shows some fine examples—the prominence of a lofty tower of some kind in the foreground, which crosses the whole picture and throws back the distance. There is a fine instance of this in No. 364 of the Turner water-colours in the National Gallery; and No. 276 is a fine example of another rather favourite treatment of Turner's—the piling up of a castle or a powerful group of buildings on an eminence in the very centre of the picture, to which everything else is subordinated. This treatment is also seen in the beautiful miniature landscape in Raphael's little picture called the "Vision of a Knight," No. 213 in the National Gallery, where the effect of the castellated rock is contrasted with that of the humbler houses seen nestled in the valleys beneath. The effect of a whole town clustered into a valley in this way is very picturesque, giving a home-like air of repose and security; there is an instance of this in Gaspar Poussin's large picture, "An Italian Landscape," No. 161 in the National Gallery. A charming instance of this effect is to be seen from the top of the hill to the east of Hastings, beyond the old town, where you look down and see the old town in the hollow between the two steep rounded ranges of grass-covered hills, as if the town had all flowed down to the bottom and remained there like water in a lake. For what may be called an effect of level and parallel composition there is nothing more perfect than is to be seen in various corners of Cambridge; the quiet-looking level ranges of buildings seem to go so well with the beautifully-kept green lawns; I would mention particularly the view of Clare College from the back of King's, with its white stone façade, combining to some extent the sentiment of both Gothic and classic architecture, rising above green verdure, and the river just by to complete the picture. I wonder this beautiful bit has not been painted oftener; the only picture of it I can remember seeing was, oddly enough, on the act-drop curtain at Toole's Theatre, during the performance of "The Don," where it was introduced, I suppose, as a piece of "local colour;" the selection did credit to the judgement of the scene painter, though the subject can hardly be said to have been done justice to.

The question of *scale* is a very important one in regard to the effect of a building on the landscape; the main point being that a building should be designed so as to show its size, and not appear to be smaller than it really is, as in that case it will tend to cause a deception as to the scale of the landscape also. I give a sketch (Fig. 18) of an extraordinary instance of this

FIG. 18.

from a neighbourhood I once spent some time in, where what appeared to be a cottage with a gabled roof was a conspicuous object on the side of a long low wooded hill. It began to strike me at last that it was curious that this cottage was always so conspicuous from all parts of the country, and at last I visited it and found it was a large engineering work, a stone reservoir with a low-pitched single-span roof and a small tower at one end of it, much farther off and standing on a much larger hill than I had ever suspected; for of course the idea that it was a cottage, which it exactly resembled in the distance, gave an entirely false conception of the scale of that portion of the landscape. This was an extreme case; but in general it may be said, the larger you can make your building appear, in respect to its actual size, the larger will the adjacent

landscape appear. A similar complaint about destroying the scale of the landscape has been made against another engineering work, not in regard so much to its design as to its actual and positive size; for a resident in the neighbourhood of the Forth Bridge works complained to Mr. Baker that he was "dwarfing the hills," which is certainly the case. However, the scenery bordering that part of the Firth of Forth is not of a very romantic character, and I confess I find the bridge the more interesting study of the two.

In regard to the harmony of tone and colour between the building and the landscape, this is best secured by using local building material where possible; and where the local material is not good enough for the purpose, by using something as nearly resembling it as possible in tone and surface. There is no material like stone for building in the country, in regard to harmony of tone and surface; since stone, however you may shape and carve it, is still a natural material with a natural tint and texture. Patent compressed brick of various types and colours may be very well in towns; it seldom harmonises with a rural landscape, as it is an essentially artificial material; and nothing can be more intrusive in a landscape than the style of modern country-house we frequently see, of what is called "brick with stone dressings," spotty in effect and showy in colour, like the mansion of the rich suitor in "Maud," which set the neighbourhood all agape:—

> "Seeing his gewgaw castle shine,
> New as his title, bought last year,
> There amid perky larches and pine
> And over the sullen-purple moor
> (Look at it) pricking a Cockney ear."

A pretentious building in a town is bad enough, but in the country it is ten times worse; it is a sin against the breadth and repose of nature; and even a building which would not be felt as pretentious amid the crowd and bustle of the town may appear so if transferred to a rural landscape.

I will now invite you to look at some views of actual scenes in which architecture plays a part, and see if we find anything there to illustrate the subject further: commencing with a few views of town effects.

Commencing again from the architectural survey of towns, the general views of Milan and of Florence may be compared, as serving to show what a grand feature a large dome forms in the *ensemble* of city architecture. Milan, with no great dome, wants the most striking feature in the views of Florence and Rome. This importance of the dome in city architecture was very well brought out by one of the architects who took part in the late competition for the proposed cathedral at Liverpool, Mr. Emerson, in the essay attached to his design, the principal feature of which was a large dome. I give a view of the dome of St. Peter's on a larger scale as contrasting with horizontal lines of building in the foreground; and the view of the façade of St. Peter's, taken centrally from a point on the axis of the building, will show at once how impossible it would be to treat that kind of architectural design otherwise than symmetrically. The view of the Panthéon at Paris, seen also centrally from the street directly fronting it, shows the same symmetrical composition, but without the special treatment of the foreground architecture so as to harmonise with the central building; instead of the decorative colonnades flanking the approach to St. Peter's, we have here only a line of ordinary street buildings on either hand; the architectural scenery is incomplete, and the centralising of the main building with the street is of much less consequence in this case, though, as the street lines are formal and regular (not like the broken skylines of Ludgate-hill leading up to St. Paul's), there is some logical reason for the symmetrical treatment of the building in relation to the street. The arch and the two columns of the Place du Trône form an example of formal and symmetrical architectural composition arranged purely for effect—somewhat academical perhaps, but still with a certain stateliness of effect which has its value at occasional points in a city. The views showing the Vendôme Column, Venice with the Campanile prominent, and Westminster-bridge with the Clock Tower seen at the end of it, all serve to illustrate the fine effect of vertical objects rising in contrast to horizontal base lines; but in the case of the Westminster Clock Tower, seen from the further side of the river, it will be observed that the effect of the Clock Tower in this respect is much diminished by the pavilion towers at the adjoining end of the Houses of Parliament interposing, from this point of view, so as to dispute supremacy to some extent with the Clock Tower. If you want a tower to tell powerfully, keep everything in the same view rather low, so as not to interfere with it.*

* An illustration of this is furnished by the different effect of "Cleopatra's Needle" as seen looking along the Thames-embankment, where its height tells very effectively, and as

The contrasting effect of a horizontal and vertical style of architecture is well shown in the view of the Palais de Justice at Paris, with the Sainte Chapelle rising behind it; the two are entirely out of keeping in style, no doubt, but in composition they help each other. A street view in modern Paris will furnish us with an example of the dead effect of long horizontal street buildings with no variation in skyline or design, as contrasted with the picturesque effect of a view in one of the streets of Ghent, with its succession of gabled houses all with a certain harmony of style and manner, but each with its own special interest in design and detail. The view of one of the quays at Amsterdam shows the picturesque combination of architecture, trees, and shipping, seldom seen in England, though Great Yarmouth, so curiously Dutch in some of its characteristics, affords an instance of it. The view of High-street, Oxford, a street the picturesque beauty of which has been consecrated by a splendid line in one of Wordsworth's finest sonnets—

> "The stream-like windings of that glorious street"—

and of which an eminent German art-critic (Dr. Waagen) said that it "had not its equal in the whole world," is as fine an example as we could have of the beauty of a street of fine buildings laid out in curves in this manner.*

The view of the main street at Innsbruck, with the mountain filling up the background, and the monumental column in the centre of the street relieved against it, is probably one of the finest combinations of town and natural scenery in existence, and may form a kind of connecting link between the town and the country portion of our illustrations. But we may properly commence our country architecture illustrations with some cottages (from the New Forest) representing the simplest type of rural buildings: a nest rather than a house —the beauty of which is that, being a habitation made by human hands, it nevertheless appears to be actually blended with nature, so that all sense of its being an architectural intrusion on the landscape is lost. Two small Thames-side country inns illustrate the most simple style of rural architecture; though more architectural than the previous cottages, they are without "design" in the usual sense, and it is this absence of symmetry or consciousness of design which harmonises them with the quiet landscape in which they stand:—

> "rura quæ Thamesis quietâ
> Mordet aquâ"——

to adapt Horace a little. The views of part of the buildings at Wadham and Brasenose Colleges exhibit an architecture equally quiet and unostentatious in regard to detail, but with that degree of symmetry which harmonises it with an artificially formed site and with carefully kept lawns; while the new buildings of Keble College illustrate want of repose in a similar situation; admirable in their way, these are essentially street architecture for a crowded town, and the bustle of detail and wall-patterns everywhere is quite out of harmony with the character and feeling of an old collegiate town. Take bridges, again, which are a form of architecture very closely connected with landscape: The old one-arch bridge of Doon, which may be said to represent the most abstract form of bridge building, is perfectly devoid of architectural pretence, but there is a certain character in the bold sweep of its arch, and it rather adds to than interferes with the beauty of the romantic scenery in which it is introduced. A common modern contractor's bridge, with a thin iron railing on the coping, like that of which I exhibit a view (over a waterfall near Spa), shows how this kind of bridge can vulgarise even so beautiful a natural object as a waterfall. Some of the Thames bridges form a kind of transition series from one stage to the other: at Wallingford and Sonning we have the solid but unostentatious form of stone bridge which painters find delightful—it is not the best practical form, certainly, for it interrupts too much of the waterway: Kingston and Richmond bridges are fine examples of a more stately order of picturesqueness; London-bridge, in its stern unadorned massiveness, and the grand sweep of its arches, is, as Street said of it, "a sublime bridge." In contrast with these we have the modern railway viaduct, a straight bar carried across the river on the top of a set of iron funnels; or we have such a piece of gimcrack design as Chelsea Suspension Bridge with its pepper-box turrets, a blot on any picture; or the still worse vulgarity of the new Hammersmith-bridge, built up with iron plates to imitate stone, and with gigantic iron castings like carved consoles; bad even if they were really carved, as out of all scale; ten times worse as cast imitations.

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seen looking from the terrace of the Adelphi, where it is brought into competition with the shot tower on the other side of the river, which nearly neutralises its effect.

* The effect of a slight deviation from a straight line is seen in coming westwards along Fleet-street, which takes a slight bend southwards at the end next the Law-courts, so slight that one would not notice it except on looking along the street; but the bend is sufficient to bring the Law-courts tower into the centre of the vista, whereas it would otherwise have been half hidden by St. Dunstan's tower: as it is, both are seen in combination.

As an example of the effect of a bridge in composition with other architecture, nothing could be more charming than the view of Hereford Cathedral and bridge from the river, the cathedral rising above the bridge, as described in a passage in Tennyson (who is full of fine bits of "architecture and landscape"):—

> "A slow broad stream,
> That, stirred with languid pulses of the oar,
> Waves all its lazy lilies, and creeps on,
> Barge-laden, to three arches of a bridge,
> Crowned with the minster-towers."

The views of Richmond Castle and bridge, and Twisel-bridge with the château seen over it, form two other examples of this kind of combination.

Water in combination with architecture lends itself very well to symmetrically planned effects, as in the view looking up a long straight canal near the Hague, with a distant tower placed (whether designedly or not) exactly axial with the line of the canal. A comparison of one or two classic buildings in connection with water, as the House of Representatives at Brussels, and Fontainebleau reflected in its moat, with Gothic examples in a similar position, seems to show that Classic architecture goes best with such a situation; the East-gate at Delft, and the Water-gate at Hoorn, are most picturesque in themselves, but they hardly seem to gain so much from juxtaposition with water. Various lake scenes which are exhibited bear out, I think, what has been said as to the pleasing effect of low level architecture by the margin of a lake, and sheltered by hills; and in one or two examples, as in the view of Goarhausen and Katz Castle, we see the same contrast that has been previously referred to; the level and quiet-looking buildings at the foot of the hill; the massive, rock-like castle near the top. The view of Villa Clara at Baveno, embowered in trees, shows exactly the kind of building that is not suited to such a site; a piece of spikey modern Gothic, completely out of place among trees.

The views of Norham and Neidpath show how well this massive castellated architeture goes with hilly scenery; and in a few continental mountain scenes that are shown will be seen examples of the simple and rather rustic kind of church spire which is frequently built in hilly country, where, as before observed, a spire of the monumental type is rarely if ever found.

The temple of the Sibyl at Tivoli is a remarkable instance of a very delicate and graceful bit of Classic architecture placed on a precipitous rock; the character of the scene, however, is softened by the masses of foliage which enter into it, and the temple does not look out of place in it; it perhaps wants a little more architectural connection with the rock. The Parisians have made a sort of pseudo-edition of this effect on the hill of Buttes-Chaumont; not nearly so fortunate an experiment as another little pseudo-temple, that on the wooded island below Henley regatta-course. In reality of course this is a mere bit of Classic sham, very bad in detail; but as seen from a distance, it is so charmingly placed that one can only wish it was a real architectural "event" in the scene.

The views of the remains of some of the Cistercian abbeys—Tintern, Byland, and Fountains—illustrate what has been said as to the harmony of this early Gothic architecture with the secluded and wooded scenes in which these abbeys were mostly built. Norwich and Salisbury show the effect of lofty pyramidal buildings; and Durham and Lincoln that of towered cathedrals, of square and solid design placed on high ground.

The early mediæval castles, with their massive towers and absence of any obtrusive architectural detail, form very important objects in a landscape, and when placed, like Kenilworth and Corfe, on a boldly-rising site, they nearly always have a fine effect in the scene. The Norman tower at Kenilworth is like the cottages before shown, an instance of a kind of *rapprochement* between nature and architecture, though in a very different sense: it is so massive in construction, so broad and simple in design, that it rather suggests a natural rock than an artificially erected building. A castle of this type in a flat landscape loses much of its effect, and perhaps nothing in the way of architecture and landscape can look more waste and melancholy than Bodiam Castle with its blank masses of wall rising out of marsh and water. The view which I give of part of Carisbrook shows how well, on the other hand, this massive castellated architecture combines with thick foliage. In the view of the remains of Launceston Castle, we see nature finally re-asserting her reign; all the architectural form of the walls and towers remaining is obscured under the soft rounded outlines of the foliage growing over it, and before a very long time has passed, if it is left undisturbed, there will be nothing to show that there was ever anything but a green hill. We began with cottages so simple in

character as to seem almost a part of the natural landscape; we end with an example in which the landscape is quietly taking the building, once a giant intruder, under its green mantle and assimilating it. We may discuss the relation of architecture and landscape on equal terms, if we please; but nature bides her time, and after a few centuries more or less (nothing in her annals) the architectural addition is gently effaced from the scene, and man has to begin his combinations of "architecture and landscape" over again from a new starting-point.

DISCUSSION.

Mr. LEWIS DAY said he was much interested in the paper, and all the more because throughout it flattered a pet heresy of his own, namely, that the most beautiful effects of architectural composition were flukes; they had happened so through circumstances that the artist had more or less taken advantage of, but that some of the best things were those which he did not foresee. He was sure that was so especially with regard to towns. Of course in the case of a single building you must give the architect the credit for all that was there, but in the case of a town no one man was responsible. These views which had interested them all much had emphasised that fact. The point of view had so much to do with it; but that was not the point of view of the designer, but of the artist, photographer, or painter who took the scene. He had often heard from artists who painted architecture, such as Mr. Fullilove, Mr. Donaldson, and others, the trouble they had to get the right point of view for the picture which had given so much pleasure.

Mr. RUDDLE had listended with much pleasure to the paper, and agreed with it in the main, but wished to make a remark or two with respect to Peterborough Cathedral. Some fifty years ago he saw an old drawing which showed an octagon turret upon the top of the central tower where the transepts crossed the nave and choir; and only yesterday he saw an old oil painting representing the same sort of thing which recalled it to his mind. Originally there was a low octagonal tower upon the square tower which has recently been rebuilt, and there was also a spire on the north-western (belfry) tower on the front—a wooden spire covered with lead. That he remembered his grandfather told him, and he believed it was taken down within his memory; this was also shewn in the drawing referred to. The main principles to be borne in mind with respect to architecture and landscape were the horizontal and vertical. That was seen in nature. A poplar tree grew with facility on low lands, and in the cedar you have the grand horizontal lines. The reproduction of the principle of the poplar was seen in the delicate tall spires which were used in low lands; in the Greek temple that of the cedar. He quite agreed with the author that when architecture was introduced into landscape in a happy way it was not a fluke. He would rather give architects the credit of studying the forms of the landscape they had to deal with, and making their buildings correspond and harmonise with them in the same way as the ancients did.

Mr. LEWIS DAY wished to explain that he did not mean to say that the effect of architecture in the landscape was a mere fluke, but that some of the best results of composition, as far as towns were concerned, especially were more a matter of accident than anything else.

The CHAIRMAN, in proposing a vote of thanks to Mr. Statham, said he thought all would admit the value of Mr. Lewis Day's remarks with regard to flukes, and also the admirable manner in which he was answered by Mr. Ruddle, while with Mr. Day's explanation they were enabled to thoroughly understand the matter. At the same time one of the chief reasons for thanking the reader of the paper was that he had endeavoured to draw out the underlying principles which would guide them in the future, and help them to take advantage of the experience of these flukes, and other things, which had come together, partly of their own accord, but really by some over-ruling providence. With Mr. Statham's aid it was to be hoped a lesson would be drawn, how to take advantage of opportunities when they did occur, for over and over again there were instances of failure to profit by such opportunities. They were always seeing public monuments put in the wrong places—not at right angles, but askew to one another; and there was a very recent instance at Hyde-park-corner, where much might have been done to improve the position, but a great expenditure had been incurred to make it worse than it was before. Mr. Statham had taken a deal of pains—not simply to select his illustrations, but to define the principles which had guided him in their selection, and showed the advantage which would be gained by attending to one or two simple laws governing the proper adaptation of buildings to their local surrounding, with the view to produce the best effect.

The vote of thanks having been carried unanimously,

Mr. STATHAM said, in regard to one remark of Mr. Day's, that most of the effects of buildings in landscape were "flukes," that it should be remembered that men like Turner and other landscape painters took the greatest trouble to put a building in the best place in their pictures, and why should not architects take the same trouble to put it in the best place in an actual landscape?

Miscellaneous.

GLOVE INDUSTRY OF PRAGUE.

The capital of Bohemia, with a population of more than 300,000, including the suburbs, has become the centre of a considerable glove-making industry. Consul Jonas, of Prague, says that the so-called French glove-making trade was introduced in that city about one hundred years ago. The ancient home industry having been ruined by the thirty years' war, like many other branches of industrial activity in Bohemia, the new start was not made until the year 1784, when M. Etienne Boulogne came to Prague from France and established the first glove manufactory, not only in that city, but in the whole Austrian Empire. The condition of the glove-making industry of Prague, at the close of the first century of its existence (1884) is shown by the following figures. There were 120 firms engaged in the manufacture of gloves, employing 586 workmen, 225 apprentices, and 65 cutting machines, and producing yearly 300,000 dozen of gloves, valued at 3,000,000 florins, the florin being equivalent to one shilling and eight pence. At the present time there are 125 firms, the great majority having only small sized shops. Not more than four or five of them employ twenty-five workmen, or over, and they are ranked among large factories. In round numbers about 600 men and 300 boys, besides about 1,200 seamstresses, find employment in the trade. The annual production is about 400,000 dozen, worth about 4,000,000 florins. The leading firm of Prague employs about 80 men in the factory, and ships about 35,000 dozen to England, and 8,000 to America. As a rule only common goods are made in Prague, the manufacture of which does not require the employment of skilled and expert seamstresses. Consequently the finest sorts, or Piqué gloves, are still imported from France and England. Apprentices in this trade must be at least fourteen years of age, and they are indentured for from three to four years. Sewing is done on machines by women, and the machine does everything except embroidery. The wages paid to men for cutting are at the rate of one florin for every dozen pairs of two-button gloves. A good workman cuts thirteen or fourteen dozen pairs a week, working ten hours daily, and with overtime work he cuts fifteen to eighteen dozen a week. Foremen instructing five or six apprentices are paid from twenty to twenty-five florins a week. For sewing, women are paid at the rate of nine kreuzers for each pair of four-button gloves, and ten kreuzers for six button gloves, and the day's work of a good seamstress is on the average fifteen to twenty pairs. The work of sewing is, however, subdivided. One person makes holes, another performs the sewing and hemming, and the third embroiders, so that a seamstress must have two assistants. The embroidery is paid according to strength of silk, from eighty kreuzers to two florins a dozen, including the material; for the work exclusively, only twenty-four to thirty-six kreuzers a dozen is paid. Hence the wages of the seamstress are reduced by the amount she pays her assistants, and they are also reduced through the system of middle men, or "sweaters," which, says Consul Jonas, obtains in this trade. On the whole the earnings of a good seamstress do not exceed six or seven florins a week.

NEW SILKWORMS.

In Germany, for some years past, efforts have been made, and with considerable success, to acclimatise the oak silkworms of China and Japan—*Attacus Pernyi* and *Attacus Yama-mai*. They have been raised in the open air, protected from the attacks of birds by nets of gauze or wire, changed from place to place as the oak leaves are consumed. Late frosts and excessively dry weather have been injurious in depriving the worms of food. In California a new wild silk moth, before unknown, has been found thriving on the poisonous species of *Rhamnus Californicus* or *R. Purshianus*. It produces a silk as good as that of the domesticated Bombyx. Owing to the favourable nature of the climate, without the frosts or rains of China and Japan, great hopes are obtained of propogating this species. In Yucatan a wild moth has also been met with, somewhat allied to the mulberry worm, which produces silk of a bluish tint, but the gum which envelops it is difficult to remove.

Mr. John MacIntyre, a recent traveller in Manchuria, records having met with several new species of silkworm, which he describes in the *Chinese Times*. One wild worm feeds on the *Pinus chinensis*. It forms handsome cocoons, which yield a strong silk, but they are so mixed up with the needle-like leaves of the pine, that the winding off the silk would be difficult. On the walnuts he found another, which forms a reticulated cocoon, like a Chinese lantern. He also met with two other species of mulberry worms, one very hardy, which could be fed on lettuce or dandelion leaves, and remains stationary, the other which moves easily from branch to branch in search of food. The rearing of *Attacus orizaba* of Mexico is to be attempted in France.

Obituary.

WARREN DE LA RUE, F.R.S.—Warren De La Rue, D.C.L., F.R.S., Ph.D., who died on Good Friday, 19th inst., was a member of the Society of Arts for several years, and sat on the Council from 1852 to 1855. The last time that he presided at a meeting of the Society was on April 16, 1875, when

Mr. John Spiller read his paper on "Recent Advances in Photographic Science." He was the son of the late Mr. Thomas de la Rue, and was born in Guernsey, in the year 1815. He was educated in Paris, and succeeded his father as head of the firm of Thomas de la Rue and Co., from which he retired in 1880. He acted as juror and reporter in the Department of Class XXIX. in the Great Exhibition of 1851, was a juror in Class X. of the Paris Exhibition of 1855, and presided over Section B, Class XXVIII., of the Exhibition of 1862. In 1860 he went to Spain with the Himalaya Expedition, and was successful in obtaining a series of photographs of the total eclipse of the sun on July 18. The results formed the subject of the Bakerian lecture, delivered to the Royal Society in April, 1862. In conjunction with Professor Balfour Stewart and Mr. B. Loewy, he published "Researches in Solar Physics," founded on observations made at the Kew Observatory under his directions. He also took an active part in making the preparations for the photographic observation of the transit of Venus in 1874. He established a private observatory at Cranford, Middlesex, but it was dismantled in 1873, and the instruments presented to the University of Oxford, where they have been employed most successfully by Professor Pritchard in determining, by means of photography, the distance of 61 Cygni and other fixed stars. In 1874 he fitted up a private physical laboratory, where, employing a battery of 15,000 chloride of silver cells, he, in conjunction with Dr. Hugo Müller, carried on an elaborate series of researches on the electrical discharge. The results of the researches were communicated to the Royal Society and the Académie des Sciences, Paris. He acted for some time as honorary secretary of the Royal Astronomical Society, of which he was also president from 1864 to 1866. He was president of the Chemical Society from 1867 to 1869, and again in 1879-88. He also filled the offices of president of the London Institution, and secretary of the Royal Institution. He was a corresponding member of the French Académie des Sciences, for the department of astronomy; also of the Imperial Academy of Sciences, St. Petersburg, and other foreign societies. Three foreign orders were conferred upon him:—Commander of the Legion of Honour, Commander of the Order of St. Maurice and St. Lazare, and Knight of the Order of the Rose, Brazil.

Captain Stab.—The telegraph announces the death at Smyrna, on the 19th, of Captain S. Stab, Corresponding Member of the Society of Arts, and author of several statistical and other papers in the *Journal*. He was much referred to as an authority on the finances and resources of Turkey. His chief production in this way was his share in the standard work in French of the Chevalier de Scherzer on Asia Minor. Simon Stab (Simon Bey) was born at Marmerash, in Transylvania, September, 1836, and joined the Hungarian army of independence. As an exile, he passed with the same rank into the Turkish service. In the Crimean war he was received into our service, and was with the headquarters staff of the artillery during the whole siege of Sebastapol. After the war he was employed by the Foreign Office under his friend Gordon, on the Armenian Boundary Commission, and with him made one of the early ascents of Mount Ararat. On his marriage, declining a Consulate, he was engaged on the Smyrna and Aidin Railway. When Mr. Hyde Clarke was Cotton Commissioner for the Porte and the Cotton Supply Association for Turkey and Egypt, called by the people Pamub Pasha, or Cotton Pasha, Captain Stab acted as Assistant-Commissioner. He was, subsequently, for many years the agent of the Council of Foreign Bondholders in Turkey, and conducted important negotiations. Latterly he held the nominal appointment of Consul-General for the Republic of Liberia, and negotiated a treaty of commerce with the Porte. He is recorded in the "Roll of Honour," by P. L. Simmonds, as a Knight of the Mejidieh of the Fourth Class, and held other Turkish decorations, besides the Crimean medals. He was also a member of learned societies, and a Director of the Messina and Adana Railway.

General Notes.

Russian Distilleries.—According to a report lately issued by the Russian Department of Indirect Taxation, there were in 1887, 2,775 distilleries in Russia, chiefly engaged in producing spirits from fruit. Compared with the preceding year, the number of these distilleries increased by 483, that is about 21 per cent. This branch of industry is principally concentrated in the Caucasus, where it is rapidly becoming extended. The province of Elizabethpol takes the first place with 1,265 distilleries, then follows Tiflis with 491, Baku with 465, Erivan with 218, and the territories of Koutais and Daghestan with 108. Among the 2,775 distilleries in question, the industrial establishments, properly so called, amount to the number of 260. The product of the distilleries amounted in 1887 to 39,924,903 degrees of alcohol, which yielded to the treasury a sum of 924,805 roubles in excise and other duties.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday evenings at Eight o'clock:—

May 1.—"Secondary Batteries." By W. H. Preece, F.R.S.

May 8.—"Origin and Manufacture of Playing Cards." By George Clulow, F.R.G.S.

MAY 15.—"The Use of Spirit as an Agent in Prime Movers." By A. F. YARROW.

MAY 22.—"Automatic Selling Machines." By J. G. LORRAIN.

MAY 29.—"The Science of Ventilation as applied to the Interior of Buildings." By D. G. HOEY.

APPLIED ART SECTION.

Tuesday evenings, at Eight o'clock:—

MAY 14.—"Venetian Glass." By DR. SALVIATI.

FOREIGN AND COLONIAL SECTION.

Tuesday evenings, at Eight o'clock:—

APRIL 30.—"The Northern Waterway to Siberia." By CAPTAIN WIGGINS, F.R.G.S. COLONEL SIR OWEN TUDOR BURNE, K.C.S.I., C.I.E., will preside.

INDIAN SECTION.

Friday evenings, at Eight o'clock:—

MAY 3.—"The Karun as a Trade Route." By MAJOR-GENERAL SIR R. MURDOCH SMITH, K.C.M.G. SIR LEPEL GRIFFIN, K.C.S.I., will preside.

CANTOR LECTURES.

The following course of Cantor Lectures will be delivered on Monday evenings at Eight o'clock:—

H. GRAHAM HARRIS, M.Inst.C.E., "Heat Engines other than Steam." Four Lectures.

LECTURE I.—MAY 6.—Introductory—Definition of a heat engine—What is heat—Count Rumford's experiments—Davy's experiments—"Heat a mode of motion"—The big gun the simple heat engine—Conversion of heat into work, and of work into heat—Specific heat—Latent heat—Carnot's doctrine—The ideal heat engine, reversible—and impossible—Absolute zero—Steam-engine as a basis of comparison—Heat units—Joule's equivalent—Available heat—Real efficiency of steam-engine—Other heat engines eliminate boiler—Effects of expansion.

LECTURE II.—MAY 13TH.—Boyle's law—Gay Lussac's law—Expansion—Indicator diagrams—Watt indicator—Original instrument—Richards—Modes of testing engines—Balance-sheets—Division of classes—Hot-air engines—Types of these—Use of regenerator—Stirling—Bucket—Ericsson—Bailey—Rider—Other engines—Possible efficiency—Actual efficiency—Losses—Practical difficulties—Modes of overcoming these—Suggestions for improvement.

LECTURE III.—MAY 20TH.—Gas-engines—History—Lenoir—Hugon—Electrical firing—Direct flame firing—Otto and Langen—Bischoff—Compression—Crossley—Crossley's igniter—Clerk—Atkinson—Griffin—Other engines—Turning effort on crank shaft—Possible efficiency of the gas-engine—Actual efficiency—Losses—Practical difficulties—Modes of overcoming these—Suggestions for improvement—Crossley's compound gas-engine—Turning effort on crank shaft—Application of the regenerator—Siemens's regenerative gas-engine—Dowson gas—Water gas.

LECTURE IV.—MAY 27.—Petroleum-engines—Brayton and others—Other forms of heat-engines—Gunpowder pile-driver—Guncotton-engine—Honigman's caustic soda engine—Mixed air and steam-engine—Ether and steam—DuTrembley—Recent American experiments—Yarrow—"Arktos"—Electrical heat-engines—Thermopile—Edison—General conclusions.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, APRIL 29...Farmers' Club, Salisbury-square Hotel, Fleet-street, E.C., 4 p.m. Mr. Westley Richards, "The Advantages of Selling Cattle by Live Weight."

TUESDAY, APRIL 30...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Foreign and Colonial Section.) Captain Wiggins, "The Northern Waterway to Siberia."
Royal Institution, Albemarle-street, W., 3 p.m. Dr. J. P. Richter, "The Italian Renaissance. Painters: their Associations." (Lecture I.)
Central Chamber of Agriculture (at the HOUSE OF THE SOCIETY OF ARTS), 11 a.m.
Civil Engineers, 25, Great George-street, S.W., 8 p.m. 1. Discussion on Sir Nathaniel Barnaby's paper, "Armour for Ships." 2. Mr. W. H. Greenwood, "The Treatment of Steel by Hydraulic Pressure."

WEDNESDAY, MAY 1...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. William Henry Preece, "Secondary Batteries."
Royal Institution, Albemarle-street, W., 1½ p.m. Annual Meeting.
Mechanical Engineers, 25, Great George-street, S.W., 7½ p.m. Inaugural Address by the President, Mr. C. Cochrane.

THURSDAY, MAY 2...Sanitary Institute, 74A, Margaret-street, W., 5 p.m. Dr. Bushell Anningson, "Rural Epidemics."
Royal Institution, Albemarle-street, W., 3 p.m. Mr. E. Muybridge, "The Science of Animal Locomotion in its Relation to Design in Art." (Lecture I.)
Mechanical Engineers, 25, Great George-street, S.W., 7½ p.m. Professor Alexander B. W. Kennedy, "Research Committee on Marine-Engine Trials; Report upon Trials of the s.s. *Meteor*."

FRIDAY, MAY 3....SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Indian Section.) Major-General Sir R. Murdoch Smith, "The Karun as a Trade Route."
Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting, 9 p.m. Sir Henry Roscoe, "Aluminium."
Mechanical Engineers, 25, Great George-street, S.W., 2½ p.m. Mr. Emil Passburg, "Description of an Apparatus for Drying in Vacuum."
Philological, University College, W.C., 8 p.m. Mr. A. J. Ellis, "Report on my Dialect Work."

SATURDAY, MAY 4...Royal Institution, Albemarle-street, W., 3 p.m. Mr. J. Bennett "The Origin and Development of Opera in England." (Lecture I.)

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FRIDAY, MAY 3, 1889.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

ART-WORKMANSHIP COMPETITION.

The objects in Pottery, Stone-carving, Wrought Iron, and Goldsmiths' and Silversmiths' Work sent in for the Art-Workmanship Competition will be exhibited in the Library of the Society during the week, Monday, May 6th, to Saturday, May 11th. Open Tuesday, Thursday, and Saturday, from 10 a.m. till 6 p.m.; Monday, Wednesday, and Friday, from 10 a.m. till 9 p.m.

Members can admit their friends personally, or by the use of the usual meeting tickets supplied at the commencement of the Session.

Admission can be obtained by non-members on presentation of visiting-card.

The catalogue of the objects exhibited is printed at page 552.

PRACTICAL EXAMINATION IN VOCAL AND INSTRUMENTAL MUSIC.

The next examination in London will be held by Mr. W. A. Barrett, Mus. Doc., at the House of the Society of Arts, and will commence on Monday, 29th May.

Full particulars can be obtained on application to the Secretary.

Proceedings of the Society.

FOREIGN & COLONIAL SECTION.

Tuesday, April 30, 1889; Colonel Sir Owen Tudor Burne, K.C.S.I., C.I.E., Vice-President of the Society, in the chair.

The paper read was—

"THE NORTHERN WATERWAY," OR NEW OCEAN ROUTE TO SIBERIA.

By Captain Wiggins, F.R.G.S.

Siberia at the time of its conquest by Russia was under the sway of Mongol Tartars, the same quiet and inoffensive race of people they now are; little given to warfare, Mohamedans by religion, they continue to reside in the more central parts of those immense realms, some four millions of square miles in extent, constituting Siberia in Asia; practising the same rude arts, and following similar pastoral pursuits as did their ancestors of centuries gone by. They are, as a rule, honest in all dealings, and frugal in habits, few are to be found in absolute poverty, whilst numbers have acquired wealth; being allowed all the national benefits of Russian subjects, and the soothing influence of worshipping in their own religion, they dwell peacefully and contentedly under Muscovite rule.

Further north are to be found the several tribes of Ostjacks, Samoyedes, Tongousks, Dolgans, &c., all of the same Mongolian origin, speaking their different languages, and leading a nomadic life; possessing large herds of reindeer, subsisting entirely on the chances of the chase, they are constantly engaged in hunting, trapping, and fishing; trading with the Russian merchants in exchange for their valuable furs, &c. These children of nature are of similar disposition to the Tartars, being inoffensive, honest, and hospitable, though not of their faith, having an undefined belief in a divine being, worshipping idols, placing their trust in the powers of their "shamans," or wise men, who are supposed to propitiate their deities by certain rites and incantations.

Since the time of its acquisition by Russia, Siberia has been known to the civilised world as the "Land of Exile;" to the dreary wastes of that land of snow and ice it was that criminals—political and otherwise—were deported. These included the highest and most noble of the land. Their sufferings in those days must have been something dreadful, when no other mode of transit existed than the cruel march; but the means now at the disposal of a more enterprising and enlightened Government enables these unhappy mortals to be deported with comparative ease and comfort. Large steamers now ply for several months during the summer time on those far-reaching river systems, which inter-

sect that vast territory in a marvellous manner. By these steamers the exiles are carried to the most remote parts of Siberia. Added to this, an efficient railway system now extends from Petersburg to Tumien, a town on the Obi River.

These facilities are taken the fullest advantage of, and as regards transit, the horrors of the past no longer exist. True it is that short distances which occur now and then between the sources of the different rivers must be traversed by sledges, or, by the robust, and most desperate criminals, on foot, as a part of their punishment; but in all cases where infirmity, weakness, or sickness require care and help, such is always given. All women and children are conveyed on sledges. This is authenticated by such travellers as Dr. Lansdell, Atkinson, Michies, and others. By the last-named we can see what was the state of affairs as far back as a quarter of a century ago. Referring to page 336 of his work, the "Siberian Overland Route," he says:—

"It is quite common to see wives, daughters, and mothers following their relatives to Siberia. This is not discouraged by the Russian Government; on the contrary, every facility is given to enable the families to emigrate, and they have always the means of travelling in company. The object of the Government is to colonise Siberia, so that the more people go there the better. . . . Two old ladies I particularly noticed coming out of the boat, accompanied by two soldiers. They were both well dressed in black silk, and warm fur cloaks. One of them was extremely old, and unable to walk. She stooped a great deal, and leaned on a crutch while standing on the ice. The other was also frail. We pitied these old creatures, exposed as they were, day after day, in such inclement weather. . . . They were treated with the greatest kindness by the soldiers, who lifted them carefully out of the boat, carried them to their sledges, which were in waiting, and put them in as tenderly as if they had been their own mothers. After carefully wrapping them up with their furs, a Cossack got in beside each old lady, and they drove off to Kazan."

Speaking of the Poles, the same author says (p. 331):—

"The Poles travelled in the same manner we did, in large sledges containing three or four people, sometimes more. Those who could not be accommodated with sledges had carts—none of them travelled on foot. On the whole I was surprised to find such a number of people travelling with so much comfort. The more sensible of them admit that their worldly circumstances are improved by going to Siberia. Many of them are pleased at the change, and would not willingly return home if it were open for them to do so."

With regard to prison life, we often hear sensational and harrowing accounts, such as have been lately appearing in the *Century Magazine*. But even the author of those articles admits that great efforts are being made by the Government to improve the unhappy condition of prison life. In one of his articles he reports that the kindly Governor-General, Count Ignatieff, aided by his tender-hearted lady, has gone into this question thoroughly, and made great improvements in the prisons.

We must also bear in mind the fact that confinement is only enforced upon those who are the most unruly and desperate, who would prove dangerous to the well being of officials and the public at large. All exiles who are peacefully inclined, are set at liberty on their arrival, and allowed to do the best they can for themselves with a freedom of action almost unknown in Russia proper. Excellent schools, colleges, and even universities exist in the several towns and cities, also theatres, concerts, balls, &c., are not merely allowed, but encouraged by the governors and authorities. At Tomsk Mr. Sulivan was present with me at one of the large social gatherings held weekly in the spacious apartments of the club; here we found the free Siberian and Russian mingling with the exiled Poles, &c.; the governor and his lady being entertained in the most elegant and refined manner possible. Excellent music and singing, delicate viands served in a sumptuous manner, dancing and other rational amusements, all enjoyed to the fullest.

Never can I forget the Christmas festivities at Tomsk; the happy fancy balls; merry Christmas trees on a scale seldom to be seen in our more favoured land. The hundreds of merry children, in the gayest of garments, securing their coveted prizes, and with rapturous enjoyment taking their share in the dance.

The immense new University at Tomsk is one of the finest it has ever been my lot to see; it already has a library of 60,000 volumes, embracing every modern language and much valuable ancient literature. The whole interior of the splendid building is fitted up in the most elegant and expensive manner; the private apartments of the professors, lecture-halls and chapel, &c., are examples of what might be well copied by us in England.

Proceeding on to the resources of Siberia, I will again quote from Michie's "Overland Siberian Route." On page 250, the author says (and this a quarter of a century ago):—

"On the whole, I confess that my preconceived notions of Siberia proved utterly fallacious. I had pictured to myself a barren, inhospitable climate, unfit for the habitation of any except those who were by law compelled to exist there, and who necessarily had to suffer every privation. Instead of that I found settled communities, not only enjoying all the amenities of civilised life, but living in expensive luxury, and many of them in extravagance."

This is owing chiefly to the fact of Siberia being so rich in the precious minerals. The gold regions lie scattered in all directions, from the Urals to the Altai, and immense districts in the vicinity of Yennesiesk, Krasnivrarsk, Irkutsk, on the Rivers Lena, Angara, Amoor, &c. Silver, copper, graphite, and other metals are to be found in all these districts, and abound in the river bottoms, mountain ranges, and lands far on towards the Arctic regions. The climatic conditions are invigorating in the extreme.

The cereal and agricultural districts comprise all the more southern parts, and on towards the confines of China.

The forest region extends thousands of miles, and contains the finest and largest of trees, such as the pine, larch, birch, cedar, &c., abounding with bird life, and game, and wild fruit of all kinds.

The valuable fur territories include the whole of the forest zone, together with the *tundra*, or deserts verging on the Arctic seas.

The rivers swarm with splendid fish, salmon, sturgeon, and sterlit, with many other kinds only found there.

On the sea coasts may be caught the white whale, walrus, and seals of commerce.

Centuries ago, long before Archangel was discovered to us, the Russians carried on a brisk trade from the White Sea to the rivers Obi and Yennesie, proceeding cautiously along the sea coast in flat boats through the Petts Straits (Ugor Scharr), and on to the Jalmal Peninsula; ascending the small river Uribey, hauling their boats over a neck of land, proceeding on by a small tributary of the Obi to a town named Mangasea, situated on the Taz, about half-way between the Obi and Yennesi systems.

This trade ceased as soon as it was found practicable to introduce manufactured articles, &c., cheaper and more plentifully from Europe; but to this day may be found the Russian merchants, with the same primitive means, trading with the natives of the Kara Sea for their valuable furs, &c.

Coming down to more recent times, *i.e.*, at the close of the year 1874, there was held at Moscow a grand spectacular festival, in celebration of the tricentenary of Russia's conquest of Siberia; costly and extensive preparations were made in order to constitute this a national event worthy of being handed down to posterity. The highest dignitaries of the land attended the sumptuous banquets, and took prominent parts in the entertainments which followed. *Tableaux vivants* on a magnificent scale were exhibited representing Russia's principal historical incidents during the course of those past eventful centuries. Peter the Great was there, encouraging commerce by welcoming to Cronstadt the merchants and mariners of Great Britain and Europe; the Empress Catherine receiving the keys from the conquered rulers of Kazan; Yermak, the conqueror of Siberia, accepting the submission of the Tartars at Tobolsk; the introduction of Chancelor (the discoverer of Archangel) to the Tsar of Muscovy at Moscow. The last scene being commemorative of Chancelor's brave fellow-workers in the same cause—Willoughby, Barentyzoon, and other maritime heroes, who devoted their lives to the discovery of a northern waterway to those lands of the far East. During this time of festivity Russia was much stirred with the spirit of adventure, unconscious that whilst they were thus celebrating the events of the past, a successful effort had that season been made to open out the long desired sea-route from Europe to the northern shores and mighty river systems of that land of their conquests.

On June the 3rd of this same year, 1874, there sailed from Dundee the Arctic yacht *Diana*, under my command. This steamer, manned with a crew of picked Dundee whaling men, and provisioned for twelve months, passed through Waigats Straits, or dreaded "Iron Gates," as early as June 24th, ascertaining on our way, by scientific observation, the truth of my hypothesis, that part of the warm salt waters of the Gulf Stream and equatorial currents flow into the Kara Sea through these straits, and onwards to the Polar ocean, taking with it the winter ice, and leaving an open route to the coast of Siberia (some years later than others, as is the case with Hudson Bay in the north-west), remaining open until middle or latter part of October.

Having surveyed the shores and coasts, and proceeded up the Obi Gulf for about half its distance, cruised over towards the mouth of Yennessie river, finding all open water, we proceeded home in safety, having spent some eight weeks in the Kara Sea, and thus practically demonstrated the feasibility of a sea route to Siberia.

The following year I again sailed for those dreaded shores, this time in probably the smallest craft that ever took an ocean voyage to Arctic seas. With this tiny vessel, 45 feet in length, rigged as a yawl, and manned with nine hands all told, we succeeded in demonstrating the route, and returned safely home in October.

This same season Professor Nordenskiold, of Arctic fame, followed on my path, and succeeded in ascending the Yennesie on board one of the river steamers belonging to the Mayor of Yenneseisk. The Professor returned overland to St. Petersburg, where he and I were entertained with great honours.

This led to great excitement and much interest being taken in the cause. Papers were read by the Professor and myself to influential societies, and finally the enthusiastic and generous Alexander Siberiakoff — the wealthy gold-mine owner—presented Nordenskiold with £3,000, and myself (through the agency of the *Times*) with £1,000. With this, and a like sum given me by an English gentleman, I purchased the screw-yacht *Thames*. Sailing once more under an Admiralty warrant, with the blue flag of the Royal London Yacht Club again at our masthead, we cruised the Kara Sea for six weeks, re-surveying the coasts, and ascended the Yennesie for 1,000 miles, wintered my vessel and crew in safety and comfort on the Kuriaka River, returned home overland, sledging 4,000 miles, with the hopes of persuading London merchants to send out a large steamer for cargo the next season. This proving futile, I returned by the same route, making a total of 8,000 miles sledge travelling in one winter.

The extreme pleasures and pains of this mode of Arctic travel by night and by day I shall not dwell upon further than to say that, when the roads are good, with the weather fine, it is delightful; but given bad roads, with wild weather, it is awful. My fellow-traveller, Seebohm, the ornithologist, forcibly describes it as the equivalent of "being inside a well-battered tin kettle tied to an affrighted dog's tail."

The *Thames*, having been damaged by ice, was sold for a good price to the mayor of Yennesiesk, who desired her engines, &c., for a screw-barge, my crew and self returning home overland.

The following year (1878) I again sailed from Liverpool direct for Obdorsk, on the Obi, with a full cargo of 500 tons of general merchandise, and returned to London in two months to a day with a cargo of splendid wheat, this being the first cargo ever brought to England from Siberia.

The year 1879 proved an eventful one by reason of the blunder made by some merchants of sending out five large common iron Baltic steamers, drawing 16 and 18ft. to discharge where there was not more than 11 ft. water. Not being fitted for ice work they could not pass through the "Iron Gates," where heavy drift ice was found, and with inexperienced ice captains, these vessels all returned home as they left. This serious mistake caused ridicule and mistrust, and so the route suffered, no one caring to take up the work again in England until 1887, when a few gentlemen, with Mr. H. N. Sulivan as managing director, purchased the steamer *Phœnix*, and with a cargo of general merchandise we again sailed for Yennesiesk, some 2,500 miles from the Kara Sea, where we arrived in safety and with ease on Sunday, October 9.

The excitement caused by our having again demonstrated the route was very great. After laying ship up in winter quarters, and disposing of our cargo on shore, Mr. Sulivan and myself, with part of the crew, returned home overland, Mr. Sulivan making arrangements at the different large towns *en route* for the purchase of produce, and supplying merchants who were anxious to buy for the next season's voyage.

The goods required out there comprise the whole of our manufactures, from the simplest article of necessity to the most costly of art works; not one thing manufactured in Europe that is not required there.

The summer of 1888 saw us once more on our way with the splendid Arctic steamer *Labrador*, laden with a costly cargo of general goods, gold-washing machinery, electric light and power apparatus, destined for the gold mines and towns on the Yennesie. My hearers may remember how we were detained at Vardo by the news of the *Phœnix* being wrecked on the river, and the loss of time by another steamer, the *Seagull*, having to be sent out from England; the storm that

caused her return to Vardo finally ending in our being able to accomplish no more than re-demonstrating the Kara Sea to be open, having navigated it with the *Labrador*, leaving there as late as October 1, returning to Vardo, there to ascertain the tantalising fact that the *Phœnix* (under the command of my brother) had actually arrived at the mouth of the Yennesie, and awaited our arrival there until the winter compelled her return to Yennesiesk. Before returning to Vardo, our passenger, Mr. Victor Morier, landed at the Pitt's Straits, and proceeded overland with natives to Obdorsk, on the Obi river, ascending on sledges to Tobolsk, and by overland route home to St. Petersburgh, being the first Western European who has made this remarkable journey. Mr. Philip Sewell, the botanist, was also a passenger on board.

This is the first and only break I have ever met with in my Siberian work, and should not prevent a further trial. With another well-arranged expedition, and augmented funds to support us, we hope to try again, trusting that all will go well with us, and that the benefits of commerce by this short sea route may abundantly prove that the past and present efforts have not been made in vain.

This is the story, very shortly told, of my voyages to Siberia; but there is one aspect of this work to which I should like, before closing, to draw your attention: and that is that the brightest side of commerce is the fact that it travels hand in hand with peace. What is it that makes this England of ours so essentially a peace-maker? Is it that we have less of the fighting spirit in us? Our history answers that question for us. Or is it that we have loftier principles than our neighbours? I think even we Englishmen must admit that others may have reached to our standard of perfection. The only answer to these important questions is the fact that so large a part of the intelligence, the vigour, and the perseverance of our great nation is engaged in commerce. We build ships, fit them out, fill them with our manufactured goods, send them to open out new regions, find fresh markets, bringing back to us the products of other men's industry. Millions of toilers in our great hives of industry are day by day forging links in the great chain which is to bind nation to nation, and race to race. And if only those of us who require to work for our daily bread could realise this fact in all its significance, our meanest task would become sublime in our eyes. No treaty of commerce or diplomatic arrangement can bind so closely as mutual interests in a common cause.

Now undoubtedly, owing to reasons geographical and historical, a great portion of public opinion in England and Russia regards these two countries as natural rivals, whose rivalry must some day or other lead to drawn swords. This idea I repudiate, and those who hold this opinion will perhaps bear with me if I speak a little from my own experience.

I arrived on the shores of Siberia for the first time—now many years ago—without introductions of any sort or kind. I was emphatically a stranger in a strange land. Yet she "took me in" and gave me a cordial welcome. Moreover, I must have appeared to her a queer stranger, for did I not outrage all her sense of hospitality by refusing the customary "cup of good cheer;" nevertheless, she took no offence, but "gave me drink," not merely the soothing beverage from her national "Samovar," but others delicately concocted, and all of a non-intoxicating nature, and in one pleasant household provided a banquet from which all alcoholic beverages were excluded for my sake. When epidemic sickness overtook our little band on our overland journey, she, on our arrival at Moscow, stepped in, tenderly took charge of our sick, and resolutely, though with great respect, put the rest of us, and every article of our baggage, through the disinfecting mill, not allowing us to do any of this onerous work for ourselves, nor did she suffer us to remunerate her for her exertions on her behalf. She also looked with favourable eye upon my humble attempt to bring into contact, for their mutual good, the intelligent, highly civilised, and energetic dwellers on the banks of those great Siberian rivers with the British working man. She gave me great facilities for the conduct of my business, and also for my long overland journeys. And her Imperial Societies for the Formation and Encouragement of Navigation and of Arts and Commerce conferred the honour of life membership upon me.

Thus it will be seen that my own experience makes it difficult to share the feeling of those who regard Russia in any other light than that of a friend; and I confess my inability to sympathise with those who suffer their prejudices and fears to warp their judgment to such an extent as to give rise to unnecessary panic—for it is easy in the times of panic to "let slip the dogs of war." And what that means was explained for us on one occasion by eloquent lips, now, alas! silent for ever, in words which

ran through the length and breadth of our country. "The Angel of Death has been abroad in the land; you may almost hear the beating of his wings............ he takes his victims from the castle of the noble, the mansion of the wealthy, and the cottage of the poor and lowly; and it is on behalf of all these classes that I make this solemn appeal." John Bright though dead, yet speaks to us. If we would not have this word-picture of his again realised, we must disabuse our minds of preconceived ideas, and keep our judgment unbiassed by pride, passion, or prejudice; then the great tyrant, War, will call to us in vain, and the peaceful voice of Commerce will surely find a willing ear. Let us listen to its teaching as it fell from the lips of one of our greatest living statesmen:—"The ships which travel between this land and that are like the shuttle of the loom, that is weaving a web of concord between the nations." Surely, we would all like to take some part in keeping this shuttle flying, by furthering every effort in the direction of peaceful commerce, thus adding a thread of our own to this grand and beautiful web.

Speaking on behalf of our company, which is formed for the purpose of trading with Siberia by sea, I wish to point out that in this higher aspect our small venture was not without its significance, and should our good vessel once more sail those seas, she will again carry with her what is dearer to my heart than any other—excepting only our national flag—viz., the flag of the British and Foreign Sailors' Society, the emblem of which is—not the dark angel of death with brooding pinion—but a pure white dove on buoyant wing, carrying with it on its flight the olive branch of peace; and so even the *Labrador* will "take a text," and preach a sermon from the sweetest words that ever were said or sung—"Peace on earth and goodwill towards men."

At the conclusion of the paper, Captain Wiggins exhibited and explained a large number of photographs of Siberia.

DISCUSSION.

Mr. H. N. SULIVAN said he could confirm all that Captain Wiggins had said, and, in fact, as he telegraphed home when he reached Yeniseisk, not the half had been told. When he first heard Captain Wiggins lecture four and a half years ago, having obtained confirmatory evidence of the truth of his statements from Arctic travellers, such as Commander Markham, as to the feasibility of the route, he asked him if he would go again if another expedition could be got up. Captain Wiggins said he would, but warned him of the difficulties he would encounter in raising the necessary funds. This proved quite correct, for he strove in vain in London and elsewhere for two years, and it was to the enthusiasm about Arctic work of a poor bedridden boy, son of Major Gaskell, which induced the latter to put down a good round sum as a start, that Captain Wiggins had another chance. Unfortunately this poor lad died shortly before the expedition returned. What had been said as to the friendly feeling and hospitality of the Russians was not half the truth. The enthusiasm with which Captain Wiggins was welcomed showed that his former visit had not been forgotten, and people expressed their conviction that the scheme would succeed now that Englishmen had taken it up. From the Governor-General and the Governors, who telegraphed congratulations, down to the humblest officials, everyone gave them the most cordial welcome and assistance. He was one who went to Russia with some misgivings, but he left her a firm friend, and he only wished that those who felt a little soreness towards that country would go out there and see the country for themselves, and they would soon perceive what a cordial feeling existed there towards England. The vice-consul at Moscow told him that a short time ago there were some labour riots there, when a German manufacturer was stoned and his windows broken; but an English manufacturer stood out on his balcony, and was cheered; and that, he said, was a sample of popular feeling towards the English. He thoroughly endorsed all that had been said as to the prosperity of the country.

Mr. HYDE CLARKE said he would venture to trespass on the province of the Chairman by proposing a vote of thanks to Captain Wiggins for the service he had rendered to the Society in bringing forward this subject, which was one not of local interest only, but having a very wide application. He had referred to the Hudson's Bay question, and it was rather remarkable that at this time the people of Winnipeg were making a similar effort to open up the Hudson's Bay route to that in which Captain Wiggins had been engaged in connection with the rivers Yennessee and Ob. This was a matter of the greatest possible importance, which had occupied adventurous Englishmen for about three centuries, and it was to be hoped that we should at last see those hopes realised. It was neither possible nor desirable at that late hour to go into the matter in any detail, but they were much indebted to Captain Wiggins for his very valuable contribution to their information, which was thoroughly in harmony with the genius of that place. He had referred to the work done by our great navigators a hundred years ago, and he had given in his own person an illustration of the national spirit, and had

communicated a great deal of the information which he had gained by his own enterprise and hard work.

The CHAIRMAN remarked that as the hour was late he would not detain the meeting with many observations of his own. He thought that if any members of the Society had hitherto regarded Siberia as a snow-clad and uninhabitable land, such an idea must now have been dispelled by the interesting paper to which they had just listened. Not to speak of the rich prairies of the Amur and Usuri regions, where the wild vine grew freely, there existed no doubt in Siberia proper fertile black-earth steppes or plains, covering some 25,000,000 acres of land, and ready for cultivation and cultivators whenever opportunity offered. It was true that the climate of Northern Siberia was for a great part of the year extremely severe, and that access to it by sea or land was somewhat difficult. But, notwithstanding these disadvantages, it was evident that the trade in gold, in furs, in wheat, and in other valuable commodities, was capable of considerable development in experienced hands. Whether the particular ocean highway advocated by Captain Wiggins with such earnestness was ever likely to prove acceptable to English merchants was a matter for doubt in his own mind, although the question was well worthy of the careful consideration of all societies interested in commerce. If he was wrong, however, in this opinion, and the ocean route indicated by Captain Wiggins could be successfully established, then the chief obstacle in the way of interchange of trade between England aad Siberia would obviously be removed, inasmuch as the latter country had great facilities for inland water communication. It seemed, indeed, that the Russian authorities were fully alive to this fact, judging by a statement he had recently read in a Russian newspaper that the Ministers of Ways of Communication and of Domains and Finance were about to examine a project for rendering navigable the principal rivers of Siberia, with especial regard to the feasibility of connecting these rivers, by canals, with one another, more particularly with the Yenisei. He gathered from what they had heard that evening, and from other sources, that the principal obstacle in the ocean route advocated by the reader of the paper arose from what were called the "Iron Gates," or the somewhat dangerous passage between Nova Zembla and the Waigate Island close to the Siberian main land; but he had recently examined a Russian project for a tramway or railway from a point in that mainland westwards of the "Iron Gates," to Obdursk on the River Obi, by which means the risks run from ice drifts in the Kara Sea and at the mouth of the Obi Gulf might be avoided. It was a question for experts to decide whether the transhipment of goods necessitated by this project was likely to counterbalance these risks. He felt sure the meeting, which he was glad to see was such a large one, would agree with him in thinking that the peaceful sentiments expressed in the latter part of Captain Wiggins's paper did credit to his heart and feeling, and he for one should be glad to see trade and commerce binding together for good the discordant elements which troubled this world, and thus be the means for establishing that universal bond of peace so earnestly desired by the reader of the paper. But he feared that such an idea must be relegated to some future age if the experience gained in past centuries was true, viz., that in the present condition of humanity trade and commerce were only too often, in the first instance, precursors of war and aggrandisement. We had only to examine the past history of either England or Russia to be convinced of the accuracy of this fact. Putting, however, this view of the matter entirely on one side, he ventured to think that facilities for trade, to be of any good to anyone, should be reciprocal, and he threw this idea out thus casually, because he saw many Russian gentlemen in the room to whom the hint might be useful. For instance, in Asia, Russia pushed with one hand her wares into India and other countries south of her, and made that policy an excuse occasionally for war and aggression, but with the other hand she placed every obstacle in the way of British trade reaching her own markets or those of the countries over which she exercised an influence. He mentioned this fact without any desire to disparage the Russian people, whom it was impossible not to like as individuals. But matters of policy and trade must be judged from a national point of view. With these few words he would now ask the meeting to join him in a hearty vote of thanks to Captain Wiggins for his valuable and instructive paper.

The vote of thanks having been carried unanimously,

Captain WIGGINS, in reply, said he simply claimed for the route he had described that, with proper vessels and men, it could be rendered as safe and regular as the Hudson's Bay route, which had many more dangers attending it than was commonly supposed. With regard to facilities for trade with Russia, all nations which imposed protective duties suffered much more themselves by that policy than we did. A country trusting entirely to itself very seldom succeeded as she expected, and it was only by free trade that England had attained the position she now held, though some people thought we were suffering from it. On the other hand, he agreed that free trade ought to be international, and he believed Russia was much inclined to give facilities for this new trade. They had already granted leave for certain goods to be introduced, though there were others which they desired to protect. He was told by the Consul at Moscow that there were manufactories there which would astonish him, that we had nothing like them for size, and the proprietors of those places did not want to see their capital and labour ousted by goods from Manchester or other places. But as

he told the Consul, those gentlemen need not be afraid; they could send their own goods far cheaper by sea to Siberia than they could overland. He had no desire to ruin Russian manufactures, but to aid them, if they would send goods by this route; if they preferred sending them overland that was their affair. They had to pay duty themselves in introducing goods into Siberia. Tea, for instance, paid a heavy duty; and he could deliver a pound of tea in Siberia for one rouble or two roubles which would cost three or four if sent overland. There was some tea there which cost a guinea a pound. These were points which required a deal of thought to work out, but what they wanted, to begin with, was a class of goods, such as machinery and heavy goods, which could not be got to Siberia at all in any other way. There was an enormous field, he felt confident, and he was equally confident that a trade could be carried on by this route regularly and safely, if it were done in the proper way and by proper men. With respect to the formation of a railway in the vicinity of Pitt's Straits, four questions occurred to him: (1) Would the Tundra route support a permanent railroad? (2) Would it pay? (3) Can a safe port be found for it on that western shore of Samoyede Land? (4) Can a pass of moderate height in the Urals be found for it?

NINETEENTH ORDINARY MEETING.

Wednesday, May 1st, 1889; MICHAEL CARTEIGHE, Member of Council, in the chair.

The following candidates were proposed for election as members of the Society:—

Craven, John, Smedley-lodge, Cheetham, Manchester.
Elford, Thomas, Landore Copper Smelting Works, near Swansea.
Halder, Albert H., 10, Throgmorton-avenue, E.C.
Poole, D. Lewis, Bedford-chambers, Southampton-street, Strand, W.C.
Rose-Innes, John, B.Sc., King's College, Cambridge.
Suffield, Lord, K.C.B., 6, Chesterfield-gardens, W., and Gunton-park, Norwich.

The following candidates were balloted for and duly elected members of the Society:—

Schlich, W., Ph.D., Indian Engineering College, Cooper's-hill, Staines.
Sullivan, William Henry, 69 and 70, Shoreditch, E.
Thomas, William Frederick, Manor-house, Southall, Middlesex.
Dent, John, 8, Fitzroy-square, W.
Edmonds, Richard, Royal Arsenal, Woolwich.
Miller, Robert, 41, Albert-hall-mansions, Kensington-gore, S.W.

The paper read was—

SECONDARY BATTERIES.*

BY WILLIAM HENRY PREECE, F.R.S.

Secondary batteries are often called accumulators and storage batteries, and the general impression is that they accumulate or store that which is called "electricity." What is accumulated or stored is, however, energy in its chemical form. A *secondary* battery is really a battery pure and simple, but it differs from a *primary* battery in this, that the chemical character of the conductors or plates, and the electrolyte in which they are immersed, has been excited by an electric current which has passed through them continuously for some time; while in a primary battery the chemical affinities exist in the materials of which the cell is composed. In the language of the distinguished American, Judge Coxe, "A secondary battery is one which gives no electricity of itself, but is active only when rendered so by a current from an independent source."

Secondary batteries have become an essential feature of every properly equipped isolated electric light installation, not only for the regulation of electric currents, and the maintenance of uniform electromotive force, but to give a store of energy to draw upon at night, and when any accident or failure occurs. They are also employed for the distribution of electrical energy from central stations. They are used for ship and for train lighting, and they seem destined to solve the important question of economical traction on our tramways. They are much used in telegraphy. They have passed through a very severe ordeal of seven years' practical development in the face of determined opposition, and in spite of the prejudice resulting from disastrous commercial speculations, and from the nonfulfilment of over-sanguine hopes and hasty utilitarian anticipations.

The father of lead secondary batteries, in a scientific sense, is the eminent French electrician, Gaston Planté; but the final stroke that made the apparatus a real practical instrument was the discovery of Faure, who showed that the application of oxides of lead, in the form of a paste or cement on the surface of the lead supports, so hastened the process of formation of the plates that the battery was

* This subject has been before the Society on two previous occasions. In 1881 (vol. xxx., p 30) Professor Sylvanus Thompson read a paper on the "Storage of Electricity;" and in 1883 (vol. xxxi, pp. 1025, 1038), Professor Oliver Lodge, F.R.S., gave two lectures on "Secondary Batteries."

made a commercial and valuable instrument. Sellon, Volkmar, Swan, Julien, Parker, King, Drake, and Gorham have added so much to the mechanical details, and have done so much to remedy defects and remove faults of construction, that all we want now is to crystallise into practical language the teachings of experience.

My house has been lighted by these batteries since March, 1884, now five years ago. I commenced with seventeen Planté cells, manufactured by Elwell, Parker, and Co., of Wolverhampton, charged by currents from a dynamo driven by a two horse-power gas-engine, but after two years of experimenting I selected twenty-six cells of the 15 L. E.P.S. type, with which form of cells I am now working. Their value can be illustrated by the following fact:—On March 30th, my gas-engine broke down. I quite forgot to give notice to the makers to send down men to repair it until six days had elapsed. It took five more days to repair the engine, so that for eleven days I had not been able to re-charge the cells; but during all these days the light never failed, and we were not in any way inconvenienced. The useful capacity of my cells is 330 ampère hours, and my nightly consumption is now about 30 ampère-hours. This was a very good test of the efficiency of the cells, for I obtained from them nearly all the energy they could usefully give. Only two cells were really exhausted during this time, but as I had two spare cells to replace them, their exhaustion did not cause me any inconvenience. The E.M.F. fell to 1·8 per cell, and the light in consequence was not so brilliant as usual. A good practical test of the efficiency of a battery like this is better than any isolated tests on single cells.

The illumination of this hall (Society of Arts) is regulated by 58 E.P.S. cells, of 13 L. type (an obsolete form), which are used, when the hall is not open, to light the secretary's and the general offices. They have been at work here since January, 1885, and have given no trouble and very great satisfaction.

Types of Cell.

There are several kinds and types of cells in use at the present day, but the principal ones supplied in England are by the Electrical Power Storage Company and by Elwell-Parker Company, Limited. The E.P.S. cells are of several patterns:—

"L."—Stationary cells used for electric lighting, motive power, and general purposes.

"T."—Portable cells used for tram-car and launch propulsion.

"C."—Portable cells for railway-carriage lighting.

Of the "L" pattern the following are the sizes issued:—

No. of Plates.	Weight.	Maximum Rate of Discharge (ampères).	No. of 10-candle power lamps (26 cells).	Capacity. (ampère-hours.)
	lbs.			
7 L	68	13	21	130
11 L	101	22	36	220
15 L	128	30	50	330
23 L	211	47	76	500
31 L	265	64	100	660

There are always one more negative plate than positive.

E.P.S. Type, 1888.

The plates of each cell are divided into the positive and the negative, in each case a pure lead grid being cast for retaining the paste-oxide $8\frac{1}{2} \times 9\frac{1}{2} \times \frac{3}{16}$ thick, and weighing 5 lbs. The perforations or openings of the positive plate are filled with minium, while those of the negative plates are filled with litharge. The plates so prepared are then subjected to powerful currents for several hours, when the litharge (PbO) is reduced to spongy lead (Pb), and the minium and red-lead (Pb_3O_4) become lead peroxide (PbO_2). There is thus economy in reducing the lower oxide and in peroxidising the higher one. Many attempts have been made to manufacture the grids of inoxidisable alloys, such as an alloy of antimony and lead, to which mercury is sometimes added, but so far nothing seems to be superior to the pure lead itself. The principal defect has been that of buckling or deforming, and this is supposed to be due to irregular oxidisation, but no clear explanation has yet been given of the remarkable way in which lead plates curl and curve under the influence of electrolysis. Plates do not buckle when they are properly treated. It is the rough handling of cells—calling upon them to do more than they were designed for—neglecting to maintain the level of the liquid and its density that principally lead to deformation, dis-

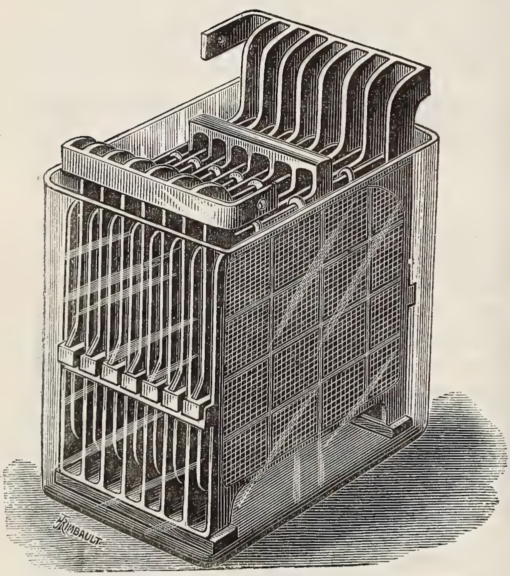
integration, and also short circuiting from the paste falling out in plugs and resting across the plates. The plates are now fixed $\frac{3}{8}$ths of an inch apart, a sufficient distance to allow any pellet that may fall out to drop harmlessly to the bottom of the cell. This distance can be increased with advantage.

The pellets of paste are now made considerably smaller than was the case at first, and this has been done to hasten the period of formation, and to render the whole of the pellet active, which was not always the case with the larger pellet, for their centres were often found unformed and therefore idle.

The negative plates of each cell rest on toes or blocks, and are maintained $1\frac{1}{2}$ inches clear of the bottom of the cell, and they suspend the positive plates by lead bars running along each side of the negative section, on which ebonite supports carry the positives. All the plates of each kind of each cell are welded or burnt on to a broad lead strip, to which either a terminal is attached, or which is burnt on to the strip of the next cell.

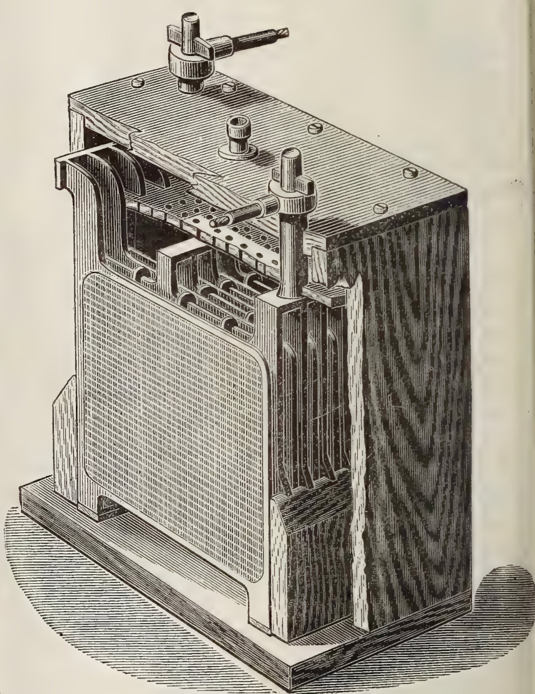
The "L" cells, for fixed permanent installations, are of glass, but for ship, tram, and train purposes they are generally fixed in wooden boxes, rendered water-tight by lead,

FIG. 1.



L TYPE (15 PLATE) GLASS CELL. FOR GENERAL LIGHTING.

FIG. 2.



L TYPE (15 PLATE) SHIP LIGHTING CELL.

marine glue, or ebonite linings. Glass is much preferable to wood, or to any opaque substance, for it is very useful to see how the plates and their packing are behaving. Elwell-Parker introduced a cell made of an inoxidizable alloy, but it has not been received with favour.

Glass has this advantage, that it is an excellent insulator, though owing to its hygroscopic tendency it has been found necessary in some cases to mount the cells on oil cups—a plan that is always necessary with wood and metal boxes.

The electrical leakage from glass cells when the acid spray is checked is very small indeed. They retain their charge unimpaired for months. It is, however, a good plan to paint the glass over with paraffin or vaseline occasionally. It checks leakage, and prevents the acid from creeping.

ELWELL-PARKER CELL.

The form of cell supplied by Elwell-Parker differs in several details from the E.P.S. pattern, though it is of the same type. The plates are held together by side frames of wood

or vulcanite at the edges so as to knit them together very firmly and prevent buckling. The whole frame of the largest size can be lifted in and out by a crane with ease. The negative plates are made in a way which prevents blistering, a defect in the E.P.S. plates, and the grids are burred in a way which prevents the pellets from dropping out. Figs. 3 and 4 show this, the one showing a section of the plate as cast, and the other the same after burring. This process, due to Messrs. Drake and Gorham, is an important improvement.

FIG. 3.

FIG. 4.

CHARGING.

The diagram (p. 544) indicates the performance of twenty-four new E.P.S. cells when freshly supplied with sulphuric acid solution of 1·155 to 1·160 density, and charged by current for the first time. It will be seen that 39 hours and an average of 30 ampères were spent in bringing them up to the mark. Thus 1·170 ampère-hours were expended in the first charge. It is curious to observe how the density fell owing to the formation of lead sulphate. The cells rested during the night. Only four cells are shown as regards density, but they were all carefully measured by hydrometer. Gladstone and Tribe* have taught us that the principal chemical change that goes on in the cell is the gradual formation and reduction of lead sulphate ($PbSo_4$), and the various changes that occur in the density of the electrolyte are due to these operations.

CAPACITY.

The capacity of a cell is the amount of energy it will accumulate and usefully restore. It is measured roughly either in ampère-hours or in watt-hours. The latter is the more accurate if the fall of E.M.F. is carefully noted, but if the E.M.F. is maintained fairly constant by not running the cells too low, the former is equally practical and more common. The average type of cell, such as the stationary E.P.S. pattern, gives a useful capacity of 4 ampère-hours per lb. of plates complete. I have had a cell (Fitzgerald's lithanode) which gave a return as high as 5·7 ampère-hours per lb., while the Planté type rarely exceed 2 ampère-hours per lb. The portable form used for traction purposes gives 5 ampère-hours per lb., but this is only because the plates are much lighter.

* "The Chemistry of the Secondary Batteries of Planté and Faure," by J. H. Gladstone and Alfred Tribe. "Nature Series." Macmillan.

EFFICIENCY.

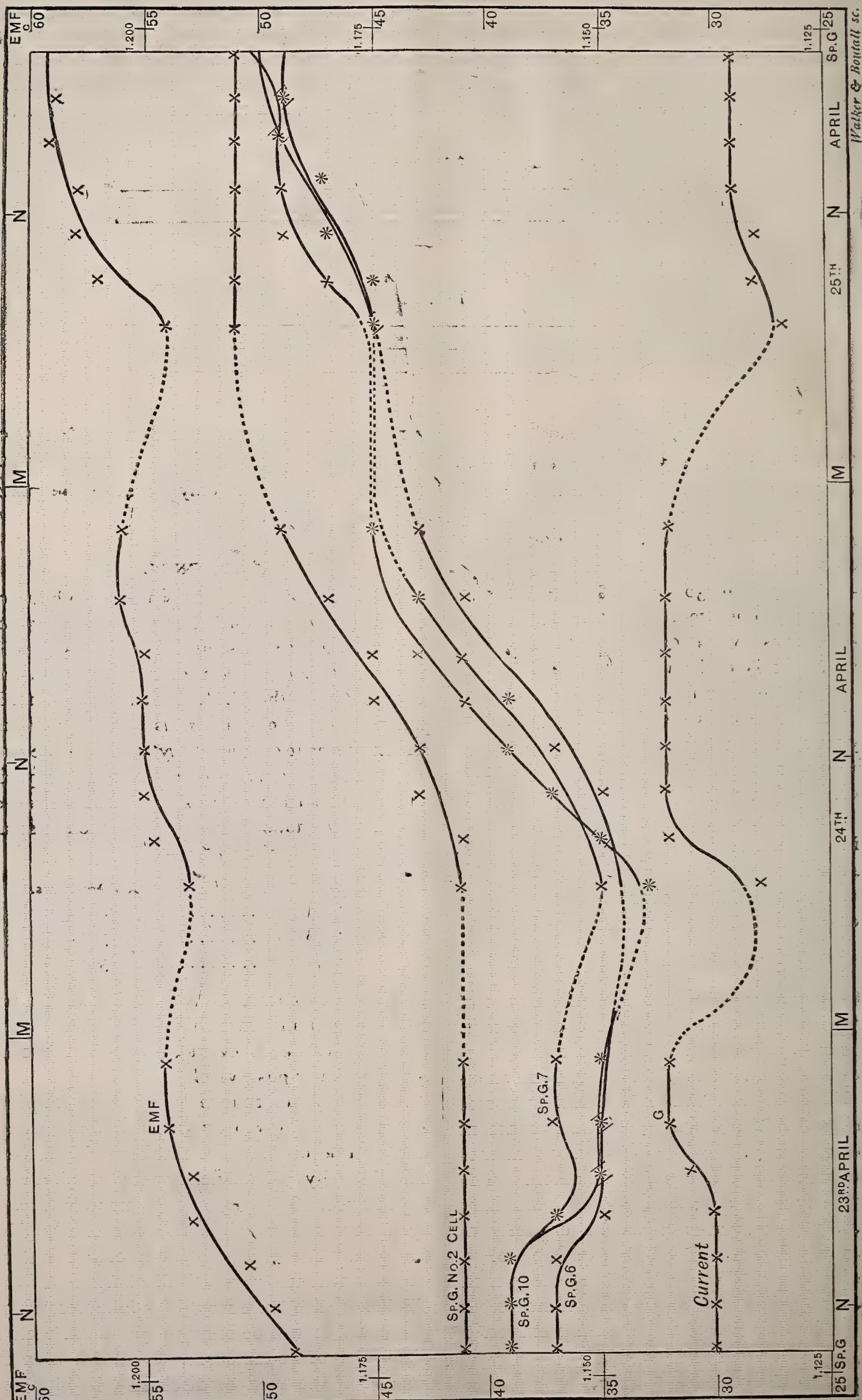
The efficiency of a cell is the ratio between the energy taken out of it to the energy put into it, and the useful efficiency is usually taken from the number of ampère-hours discharged when the E.M.F. falls 10 per cent. in magnitude. This figure is a very variable quantity, for it depends very much on the current density, that is upon the number of ampères per unit of surface—one square centimetre—of plate. The following experiment on a small cell illustrates this point:—

Current-density.	Ampère-hours.
·013	44·6
·048	36·5
·09	30·2

The ordinary current density, which should not be exceeded in practice, is ·01. This means that the maximum output should not exceed 4 ampères per positive plate.

A cell will discharge many more ampère-hours than are given by this useful efficiency, and if the discharge be taken with a very small density, the efficiency may reach a very high figure. Thus 95 and 98 per cent. have been obtained from small cells slowly discharged. The efficiency of a cell therefore varies with its rate of discharge. If the efficiency with an output of 5 ampères be 90 per cent., it will be only 50 per cent. with a discharge of 40 ampères. Batteries drop in E.M.F. if the rate of discharge is high, or the current density great. They should,

FIG. 5.


EMF
Sp.G. No.2 Cell
Sp.G.10
Sp.G.6
Sp.G.7
Current
G
23RD APRIL
24TH APRIL
25TH APRIL
Walker & Boutall sc.

therefore, be discharged at a slow rate. The most general maximum rate is found to be that which discharges a cell in ten hours. Thus the discharge of 15 L. cells should not exceed 30 ampères, nor that of 31 L. cells 60 ampères.

It is sometimes thought that because the E.M.F. in charging is 25 per cent. greater than in discharging, there must be a loss of energy to that amount, but the fact is this loss of E.M.F. is compensated for by gain of current, owing to the reduction in the internal resistance of the cell. The internal resistance of a cell, which is normally about $\cdot 0003\omega$ per positive plate, diminishes with the strength of the current of discharge, and therefore it is possible to get nearly all of the energy out of a cell that has been put into it. The efficiency of a secondary battery increases with the lightness of the load put upon it, and in this respect it possesses a great advantage over that other transformer of electric energy, namely, the secondary generator of Gaulard.

It has been the practice to place the plates in a cell very much too close to each other. This not only favours short circuiting, but it prevents the free circulation of the electrolyte. Recent experiments have also shown that efficiency has also been improved by increasing the distance between the plates. I exhibit a diagram, through the kindness of Mr. King, illustrating this useful fact—a fact fully confirmed by my own experience with Planté cells.

The Electrolyte.

The character and the quality of the electrolyte used in secondary cells has scarcely received the attention it deserves. Hitherto scarcely anything but a solution of sulphuric acid has been employed. Experience seems to show that the best solution to use before charging is one which has a density of 1·150. Such a solution in a 15 L. cell, when fully charged, will acquire a density of from 1·210 to 1·220, and it is customary to maintain the density of the cells somewhat between 1·170 and the higher figure. One of the great troubles with secondary cells that are imperfectly and improperly treated is the formation of the white sulphate of lead that is frequently seen upon both plates. In fact, it is the root of nearly all the ills that these cells are heir to. There are many ways of getting rid of this sulphating. The plan used by Mr. Sayers, the engineer in charge of the St. Pancras Hotel installation, is described by him as follows:—

"Our battery of 120 15 L. cells was rather badly covered with sulphate of lead. At first I simply charged them with the ordinary maximum charging current, 30 ampères, when each cell, on becoming full, would give about 2·5 volts. The sulphate, however, did not apparently move. I then tried charging with 40 or 45 ampères for a few weeks, and the change in the look of the plates—of the peroxide plate chiefly—was considerable. They began to exhibit patches of the well-known plum-coloured peroxide, and nearly all had the appearance of a peroxide plate covered with a lace-work of sulphate of lead. This lace-work, also, soon nearly entirely disappeared, and the majority of the plates are now looking very well. The E.M.F. of each cell, with forty ampères charging current, is about 2·7 volts when the cell is milky. I have thought that this result was due either to the fact—if it is a fact—that sulphate of lead requires more than 2·5 volts to decompose it thoroughly—say 2·6 volts—or, that the large quantities of nascent hydrogen attack the sulphate and combine, making sulphuric acid and lead."

It occurred, however, in 1886, to Mr. Barber-Starkey, of Aldenham-park, near Bridgnorth, to see if the addition of soda in the presence of lead had any beneficial effect upon plates liable to sulphating. The result was very satisfactory, and all traces of sulphating disappeared. He treated his own cells in this way, and the effect was so decidedly advantageous to all appearances, that I determined, after careful inspection and inquiry, to make an exhaustive experiment that should determine the question, and at the same time settle the best proportion to use. Six new 15 L. cells of the Elwell-Parker make were taken, and they were charged with solutions in the following manner:—

No. 1.—5	pints of	sulphuric acid,	5	pints of	sulphate	of sodium,	15	pints of water.
No. 2.—5	,,	,,	4	,,	,,	,,	16	,,
No. 3.—5	,,	,,	3	,,	,,	,,	17	,,
No. 4.—5	,,	,,	2	,,	,,	,,	18	,,
No. 5.—5	,,	,,	1	,,	,,	,,	19	,,
No. 6.—5	,,	,,	to 20 pints of water.					

The sulphate of sodium solution was prepared by first making a saturated solution of carbonate of soda (ordinary washing soda), and then adding thereto sulphuric acid until effervescence ceased. The cells so prepared have been charged and discharged, and watched with great care from May 1st, 1888, until the present day. We, therefore, have exactly 12 months' experience of their behaviour, and there can be no doubt as to the beneficial result. The solution marked No. 5 is that which has given the best results, and after about six months' experience of its behaviour, two complete sets of 52 No. 23 L. cells, were charged, the one with the ordinary sulphuric acid solution of 1·175 density, and the other with sulphate of sodium solution of 1·225 density. Six months' experience of these two sets has confirmed the result that immense benefit is to be derived from the sulphate of sodium solution. There has been no evidence of buckling, there has been little or no scaling. The bottom of the cells are nearly as clean as when they were first charged, while the bottom of those charged with the sulphuric acid solution have the usual accumulation of oxides of lead. Two cells were also, and at the same time, charged, the one with the sulphuric acid and the other with the sodium solution, and very careful tests of these two cells show that the addition of soda does not impair either the E.M.F. or the internal resistance; nor does it diminish the output of the cells. I have, therefore, come to the conclusion that the addition of soda has a distinct beneficial result, and it is my intention to use it invariably in future. The cells so provided remain in splendid condition. They can be left for months without developing any trace of sulphating or even of loss of charge. Carbonate of soda thrown into a badly sulphated cell unquestionably leads to the rapid removal of the sulphate of lead, and always produces beautiful deep puce-coloured peroxide of lead.

Mr. R. Davids writes, January 18th, 1889, to me from Campinas, Brazil:—"As might have been expected, the cells (which had been delayed in transit) were very badly sulphated, but after 24 hours charging, I gave them a dose of soda, which proved a *santo remedio*."

The electrolyte that I recommend for adoption is this:—To a quart of saturated carbonate of soda solution add slowly, during continuous agitation, 12 fluid ounces of strong sulphuric acid; fill the cell with water 19 parts, strong sulphuric acid 5 parts, soda solution 1 part; total 25 parts. The specific gravity of this electrolyte should be 1·210.

It is a mistake to use cells of too small a capacity for stationary purposes. This is usually done for economical reasons, owing to the capital expenditure involved in purchasing cells. Twenty-six 15 L. cells cost £78, and the same number of 23 L. cells cost £117; but I believe it to be true economy to expend the additional £39. Greater efficiency is obtained out of the larger cells now that soda has prevented injurious sulphating, for you are not limited to a minimum current as you are with the sulphuric acid solution. Small charging and discharging currents mean not only greater efficiency but greater durability of the plates. Secondary batteries used for telegraphy show no sign of disintegration. It is over-taxing cells that destroys the plates. Mr, Barber Starkey's cells at Aldenham-park have now been in use for three years, and to all appearances they are quite as perfect now as when first set up.

Maintenance.

The chief secret of the successful working of a set of secondary cells is careful and regular attention to their behaviour, and the immediate remedy of any defect that may develop. They require daily testing and inspection. My battery is tested every morning for E.M.F. by means of a Cardew's voltmeter. If the total number of volts divided by the number of cells is not over 2 per cent., each cell is tested separately by a portable Walsall voltmeter graduated to tenths of a volt, until the defective cell is found. This has very rarely happened, in fact only once during the past twelve months, when a plugging fell out, rested between the two plates, and short-circuited the cell.

Six cells are also tested every morning for density by a hydrometer, which is recorded in a book. The six cells are changed every month, so that each cell of the battery passes through this ordeal three times a year. The regular rise and fall of the specific gravity of a cell is the very best criterion one can have of its good working. I cannot do better than transcribe the record of one week's testing (Table, p. 547). The normal density when the cells are charged should be 1·220. They fall 1 for every 5 ampère-hours taken out, and when they reach 1·150 they are exhausted. The density is thus a record of

"GOTHIC LODGE" ENGINE ROOM.

28 E.P.S. CELLS.

Date.	Current.	E.M.F.	Cells (Density).*				
			8	14	18	20	26
April 24...	—	57·5	1210	1215	1190	1225	1225
" 25...	—	57·5	1210	1205	1185	1220	1220
" 26...	—	57·	1205	1195	1180	1215	1215
" 27...	Charging.						
7.30 A.M.	26½	60	1200	1190	1175	1210	1210
10·0	30	64	1205	1195	1180	1215	1215
12·0	31	67	1210	1200	1185	1220	1220
2·0	31	69	1210	1205	1190	1225	1225
4·0	31	70	1210	1210	1200	1225	1225
April 28...	—	57·5	1210	1205	1195	1225	1225
" 29...	—	57·4	1205	1200	1190	1220	1220

the energy that has been taken out, and of that which remains in.

Occasionally I test them for internal resistance (ρ), both when charging and discharging. In the latter case the discharge current into the house is regulated by lamps to give 10 ampères when the E.M.F. (E_1) at the terminals is read. The E.M.F., when the ends are free, (E_2), is also read. Then—

$$\frac{E_2 - E_1}{10} = \rho$$

I make the current 10 for the internal resistance varies with the current,† and by always using the same current I have an accurate comparison. The internal resistance of my 15 L. cells is usually ·0012 ohm. per cell when discharging, and ·005 when being charged.

When a cell becomes defective by short circuiting or any other cause, the plates are taken out, their faces scraped and straightened, the solution cleared, and the cell thoroughly cleaned. The cell is always benefited by such a process, for the cleaned cell is always the first to come up to the charge by as much as 1½ hour.

The cells in this building have been very carefully tended during the four years they have been at work. Only three sets of positive plates have been renewed.

In charging cells, there are three distinct indications that the cell is fully changed:—

* The density of the cells requires to be equalised periodically.

† Preece, Proc. R.S., May 6, 1885.

1. The E.M.F. suddenly rises up to 2·5 volts per cell.

2. The hydrometer indicates 1·220.

3. The electrolyte becomes milky by the fine bubbles of gas that float in the disturbed solution during their gradual ascent to the surface and escape into the air.

The rise of bubbles of gas to the surface, and their bursting, scattered a considerable amount of acid spray about in the battery room, which was injurious to metals and apparatus; but Mr. F. Higgins, Memb.I.E.E., showed how to prevent this by covering the cell with a fine net or with calico. Glass plates are now much used instead of calico, but I have adopted Mr. Henry Edmunds' plan of pouring upon the surface of the solution melted paraffin, which solidifies and coats the surface with a uniform thin layer of what looks like ice. A hole is bored to admit the hydrometer, and to allow any gases to escape.

It is necessary to be cautious in approaching cells with naked lights when they are being charged. There are several instances of explosion and injury to person in consequence. Two cases in London and two in Leeds have come under my own notice; one was in the Post-office.

The chief defect of the negative plate is that the plugging scales and falls off in thin flakes. This, in the recent types, falls harmlessly to the bottom, but it should not happen at all, and it is due either to imperfect material or to hasty formation. The negative plate should certainly last for ten years. The positive plates also disintegrate, and to a much greater extent. The disintegration of the lead peroxide seems to be necessary consequence of the action of the cell. It varies with the rate of discharge. If the cells be worked heavily it occurs rapidly, but if the maximum rate of the output of about four ampères per plate be adhered to, the duration of the plate may be taken to be three years. The decay of the positive plate seems to occur almost entirely in the lower half of the plate, and this is probably due to the greater density of the solution favouring unequal distribution of current.

CENTRAL STATIONS.

The secondary battery lends itself admirably, under certain circumstances, to the economical distribution of electric currents from central stations. It is possible to lay down a long main circuit of small dimensions, conveying a direct current of high E.M.F., which at different points can charge

a secondary battery of a small number of cells, so as to "transform" the dangerously high E.M.F. into one of a low and harmless character in the building to be illuminated. In fact, this is now being done in Chelsea by two different companies. The one company, the Chelsea Electricity Supply Company, is acting under the statutory powers of a Provisional Order, and it distributes its currents to the houses from sub-stations, where the batteries are kept and maintain a continuous supply of electric energy. Each sub-station, of which there are three, supplies current for 2,000 30-watt 10-candle-power lamps. There are 265 31L. cells, divided in two sets of groups of 53. Each set is charged separately and alternately in series from the central generating station. While one set is being charged the other is supplying currents to the consumer. The main charging current of 60 ampères has an E.M.F. of 500 volts per distributing station, or 1,500 volts for the present circuit; and the secondary discharging supply into the houses has a pressure of 100 volts. This system of distributing currents from batteries has many advantages. The currents, being direct, are available at once for motor purposes, as well as for lighting. The currents being so steady and uniform, add to the durability and life of the lamps. The supply being continuous day and night, it is always available, just as is the light from gas. The distributed currents being of low E.M.F., absolute safety to person is secured in such a system. The engines at the central station being always worked at full loads, can be worked under their most economical conditions, and as they can be worked continuously throughout the twenty-four hours, a minimum capital expenditure in engine plant is necessary. It has already been pointed out that the efficiency of the battery is not much affected by variations of its own load, and that whether one lamp or 100 lamps be used it is of not much consequence to the cells; in fact, the efficiency of the lighter load is the highest. On the other hand, it must be pointed out that there is a considerable capital outlay required in batteries. The depreciation of the cells is very considerable, and there is an appreciable loss of energy at each transforming point. The maximum efficiency of batteries in practice rarely reaches 70 per cent., while less than 15 per cent. for depreciation can scarcely be allowed with prudence. The batteries for 1,000 lamps cost £1,325, or 27s. per lamp. The reliability, constancy, and permanence of the light from batteries compensates for many another evil. The other company in Chelsea—the Cadogan Electric Supply Co.—places the batteries in the houses, and charges 1,000 E.P.S. 31 L. cells over a circuit of nine miles.

There is a central station in Detroit, in the U.S.A., also distributing by batteries, and giving great satisfaction.

The Kensington-court central station, established by Messrs. Crompton and Co., and that at Whitehall-court, also use secondary batteries, but the batteries are in the stations and not in the houses. They are used more for regulation and for reserve force purposes than for distribution.

There is also a large central station at Vienna, and one at Darmstadt of the same character.

An extremely ingenious mode of distribution has been proposed by Mr. Henry Edmunds. The battery is divided into four groups. Three groups are jointed in series, and supply energy to the house, while the fourth group is in the main being charged. These groups constantly and continously change places every three minutes by means of an automatic switch. A third of the battery is, therefore, always being charged, and this means that only one-third engine power is needed at the central station, and only one-third of the E.M.F. on the changing main. Mr. Edmunds's automatic distributor is an extremely ingenious apparatus, but it has not yet received the test of practical trial, though the sooner it does so the better.

Traction.

A very important application of secondary batteries is that of traction. In the United States this system has received immense development, but in England it has scarcely as yet grown out of the experimental stage. In London the North Metropolitan Tramways are trying some important experiments, but in Birmingham an electric locomotive has been made by Elwell-Parker, on the Julien principle, weighing 8½ tons, and worked by 100 cells, each weighing 81 pounds, which has drawn loads of 30 tons up stiff gradients, and has run 70 miles with only one charge. This system is destined to be most useful and economical, and it looks as though it would gradually replace horses for tram work.

Portable Lamps.

Two other useful purposes to which secondary cells are applied are (1) the construction of

safety lamps for miners, and (2) reading lamps for railway travellers. Since one pound weight will give a capacity of four ampère-hours (and it is easy to obtain lamps which can be incandesced with only the third of an ampère), it follows that if we use three cells, each weighing one pound, we can easily get a lamp which can be maintained alight for twelve hours, giving a light of about two candles. This is ample for both purposes enumerated; in fact, I habitually travel with such a portable railway reading lamp, and find it of immense service. The battery that I am now showing to you was charged during the last Christmas holidays. I have not travelled since, and it has not lost much of its charge, as you plainly see. I have much pleasure in exhibiting several forms of safety miners' lamps, which have been lent me for the occasion by Mr. Pitkin, their manufacturer. Mr. Swan has done much in this direction, and his lamps are in considerable use, especially in South Wales, and are now exhibited in action.

TELEGRAPHY.

All attempts to use dynamos direct for telegraphic purposes in England have failed, but their use indirectly, by means of secondary batteries, has been eminently successful. At the General Post-office, in London, there are 220 circuits thus worked from only 38 cells. The currents used for telegraphy are very minute compared to those used for electric lighting; ·05 ampère, or 50 milliampères, is a large current for such a purpose. Thus the current that would light one 50-watt glow lamp will work 10 telegraphic circuits. The secondary cells are applied thus:—20 cells provide motive power for Delany multiplex distributors, and 120 single needle circuits; 18 cells, or 2 parallels of 9 cells, provide currents for 100 direct inker Morse circuits.

This mode of working has now been in use since the early part of 1884.

It is quite clear that the secondary battery has passed through the experimental stage, and that it has now reached its commercial career, where it will prove to be a most valuable and indispensable adjunct to the equipment of the electrical engineer.

DISCUSSION.

Professor GEORGE FORBES congratulated the Electric Power and Storage Company, and Messrs. Elwell and Parker, on the enormous improvements which had been made in secondary batteries, and thoroughly endorsed Mr. Preece's opinion that the secondary battery had now completely passed out of the experimental stage. All must recognise that, especially for the numerous applications Mr. Preece had spoken of, they would be extremely valuable on account of the certainty of their action. He hoped the next improvement would be a reduction in price, and that the improvement mentioned in the solution would lead to a longer life for them.

Mr. T. R. CROMPTON said, as there had been no recent papers on this subject, those who were specially interested in the matter would have been glad to hear more details of the latest improvements. Every one would agree that the addition of accumulators, either at private houses or central stations, was a source of the greatest comfort, inasmuch as it provided absolutely against the light suddenly going out. The very worst accumulator even gave a certainty that if anything happened the light would only die down gradually; and a difference between that and a sudden extinction was so great that he only need refer to it. It was quite sufficient to save an enormous loss of life in the case of a crowded building, and it prevented that great feeling of anxiety which attached to the engineers in charge of any central station system under the direct supply system without storage; who knew that at any moment the bursting of a steam-pipe, or anything of that kind, would plunge the whole district in darkness, and discredit the undertaking for months. Even the comparatively imperfect accumulators of years ago were quite sufficient to remove that danger. The use of soda to prevent sulphating was specified some years ago by M. Monier as probably the best cure. He did not use carbonate of soda, which was changed into sulphate of soda in the presence of sulphuric acid, but advocated the addition of sulphate of magnesia or of soda; and in response to a query of his (Mr. Crompton's) he specified sulphate of soda as th best, and he had used it ever since; but he could not agree that it had no effect on the E.M.F. or the condition of the cells. The advantage derived from placing the cells further apart was brought to the notice of the Storage Company by Mr. Mellish, the engineer in charge at Vienna, who tried this for some other purpose and found to his surprise that it increased the efficiency of the cells. Mr. Preece said the depreciation of the cells was very great, but he thought that was going rather too far, as nothing was really known about it yet. The system had only been invented about four years, and many cells had lasted the whole of that time. For a long while they did not know the proper way to use these batteries, and many failures which had been laid to the charge of the cells really should be borne by the people who used them. He did not consider the depreciation, under proper management, was any greater than that of ordinary machinery.

Mr. EDWARD RILEY said he had been using these cells about two years, and was much interested in learning any method which would prevent sulphating. He understood Mr. Crompton to say that the addition of carbonate of soda really meant the addition of so much sulphate of soda, and he could not understand how that would decrease the deposit of sulphate of lead.

Sir FREDERICK ABEL, C.B., F.R.S., said he came to learn, and he had learned a good deal, amongst other things the point now under discussion, and he did not think the action was difficult to explain. It appeared probable that a double salt of sulphate of lead and sodium was formed, which was soluble, whereas the sulphate of lead alone was comparatively insoluble. He could understand, as Mr. Crompton suggested, that the action of the cell would not be quite the same if the soda salt was added in any considerable quantity. He could quite corroborate the statement also that at first they did not know how to use these batteries. At one of the large clubs there were a number of these batteries which had now been in use over three years. At first they had great trouble with them, and feared they would have to give them up, and the company which supplied them had frequently to send in to put them in order. But now they had an intelligent man who had learned to understand the behaviour of the cells, and kept them in order by very simple means; and as long as they were kept up thoroughly to their work, there was no difficulty from sulphating or any other cause.

Mr. PARKER said the chemistry of the action which took place was rather a complex subject. He used potassium and soda at a very early period, but for some reason it had not been adopted in regular practice. His idea in using it was this:—If lead were placed in pure distilled water the lead dissolved, and sulphate of lead was formed very rapidly, but the presence of salts of sodium or potassium prevented this action. At that time, however, they were only making Planté batteries, and did not suffer so much from sulphating, but when Mr. Barber-Starkey found out this mode, in the manner described in the paper, they arranged to work under his patents, and found great advantage from it. What Sir Frederick Abel had said about the formation of a double salt was well worth investigation, and he thought from his experience the suggestion might lead to something valuable. With regard to central station lighting, there were certain points which required attention. In the early period, at Colchester, the same means were used as at present, and they had to suffer the full loss of the batteries in charging and discharging on the whole supply; but he hoped they would be able to use the central station machinery for lighting, and use accumulators for regulating the supply, automatically or otherwise, and as a stand-by. If this could be done, it would bring secondary batteries into a very prominent position. With regard to tram-car work, he might say that the car built for Birmingham was made to a specification to do the work of the steam tram engines, of which there were 70 or 80 at work there. But they had beaten them, and had run for 70 miles with a single charge. The car was first put to work on the 7th November, and had been running ever since to the complete satisfaction of the company and the town authorities. He was quite sure that before long Birmingham would adopt the secondary batteries entirely for street locomotion.

Mr. RECKENZAUN said the principal defect hitherto, found in storage batteries was the buckling of the plates, which was supposed to be due to irregular oxidation, but no clear explanation of it had yet been given. His opinion was that it was due firstly, to the ordinary expansion of the active material when peroxidised. If the oxide were confined within the narrow meshes of a perforated plate, either the grid must expand, or the oxide must come out, or the frame must go; and he had found that the softer the frame was, the less deterioration it suffered from this cause. When an alloy of lead and antimony was used, he found that unless the grids were made very strong it would split, and if it did not, the oxide would go. The natural expansion of lead by oxidation was about 14 per cent. if every atom of the lead were active, but in practice not 1 atom in 10 was really active. He found a plate with a surface of 90 square inches, had grown in one year to 94·76 square inches, with ordinary use. This expansion was one cause of buckling, but a more important cause was the sulphating, and excessive sulphating generally occurred when the plates were left to stand idle after being wholly or partially discharged. The sulphuric acid then had time to combine with the lead and form sulphate in all the crevices, and thus the plate was expanded inordinately, and caused the buckling. The main thing was never to discharge a battery below a certain point, and then not to let it stand idle. He had been constructing plates very differently to any of those shown, and with very good results. They were made of a number of pencils of oxide of lead, $\frac{3}{16}$ths thick and $1\frac{1}{8}$ in. long, dried in a cast-iron mould with circular recesses. The pencils were larger in diameter than the retaining material was thick. He found that if the proportion between the active material and the retaining material—which was ordinary pig-lead—was well chosen, these plates did not buckle at all, no matter how badly they were used, and they might even be thrown about without the active material coming out. Mr. Preece had mentioned 95 to 98 per cent. as the efficiency of a storage battery, but he could not accept that, understanding by efficiency the proportion between the work expended and that returned. In charging the battery you required at least $2\frac{1}{4}$ volts E.M.F. to send a current through at all, and in discharging it you

could not get more than two volts on an average; so that if the efficiency in ampère hours were 100 per cent, the efficiency in energy could not be more than about 88 per cent.

Mr. B. M. DRAKE said it was very refreshing, when secondary generators were being pushed in all directions, to find that Mr. Preece and others still believed there was a future for secondary batteries. In installations for country houses, and large installations like that at the Prudential offices, where there were 3,500 lights of 16 candle power, it was, as Mr. Crompton had said, a great relief to know that whatever might happen to the engines, there was the means of continuing the light. At the last-mentioned place the batteries were always ready at a moment's notice, and they were used, as they ought to be, in large installations for regulators, and for the supply of lamps when only a small number were required. When worked in that way there was very little depreciation, and the interest on the first cost was more than covered by the long life of the lamps. This installation had now been in use over three years, and the average life of the lamps was over 2,000 hours, while many had run as much as 4,500. He agreed with Mr. Parker that secondary batteries used as regulators at central stations would put the system on a very different basis to the present, in which the battery was charged by the dynamo, which was then cut off and the current taken out, with the full loss of a double conversion of energy. With such a system it was very difficult to compete with the cheaper methods, but if it could be worked out on the lines just named, the secondary battery would be as cheap, if not cheaper, than the present system. With regard to the distance apart at which the plates were arranged, he had tried them from three-eighth inch downwards, but he got very different results to those shown on the board. He should repeat his experiments, but, as far as he had ascertained, there was a gain up to a certain point only, which was about five-sixteenths. At the P. and O. offices might be seen a battery which had been in constant use for five years, and not a cell had been taken out to be repaired, where the plates were arranged at practically the same distance as that which the present practice had now come back to, so that there was little claim for novelty.

Mr. FRANK KING suggested that the reason Mr. Drake's results were different from those shown in the diagram, was because the proper proportion was not observed between the distance of the plates and the size of the pellets of paste. A secondary battery ought to be used in the same manner as a gas company used a gasometer, as a reservoir, and as a means by which a constant small additional supply of electricity might be available during the hours of maximum pressure. Under such circumstances there was no doubt that a profitable return could be obtained for the capital employed, large though it might appear, and the installation, as a whole, was worked most effectively because the engines were always working at their maximum power. Storage batteries, when properly supercharged each day, would give a much higher percentage of energy than Mr. Preece stated, and might well go up to 83 or 84 per cent., but he could not see how they could go beyond. The addition of soda had generally been tried with batteries which had gone wrong, with the result that the pellets of paste had all come out.

Mr. SWINBURNE thought the difference between Mr. Preece and Mr. Reckenzaun as to the efficiency of the battery was more one of words than anything else. If you charged and discharged with a very small current you might get up to 98 per cent., but in practice it varied from 80 to 90 per cent., according to the rate. As to the advantage derived from increasing the distance, he thought it had something to do with the strength of the acid in the electrolyte. Most people used the acid rather too weak, and separating the plates merely allowed room for the available acid to act. In 1883, he made a large number of experiments on these batteries, and in 1886 he read a paper in which he pointed out that, on theoretical grounds, sulphate of soda would have the effect of reducing the sulphate of lead which was soluble in it. The same effect might be produced to some extent by using stronger acid. If you left a cell discharged, you got a lot of sulphate, but it was in a different form, as it merely arose from the soda sulphate in contact with the plate. The ordinarily precipitated sulphate could easily be reduced by mixing it with a small quantity of one of the oxides, but probably the soda was the simplest method of preventing it.

Mr. PREECE, in reply, said he must correct two fallacies, one being the assumption of Mr. King, that the sulphate of soda solution had only been applied to bad batteries. On the contrary, he had given in the paper the exact results obtained, comparing two new batteries, one with the ordinary solution and the other with the sulphate of soda, and the former was not in it. He heard of this method four or five years ago, and had been working at it ever since, or he should not have ventured to bring it forward. He did not entertain a very definite opinion on the chemical side of the question, but there was a passage in the paper which pointed very much in the direction of the explanation offered by Sir Frederick Abel. The other fallacy was one which he was rather surprised to hear propounded by Mr. Reckenzaun, though he once entertained it himself. The efficiency of a battery was the ratio between the energy taken out of it and the energy put in, and the energy in

either case was the product of two factors, the E.M.F. and the current. Mr. Reckenzaun had dealt with only one—the E.M.F. It was quite true that that was higher during charging than when discharging, but the current given out was very different. That depended on the E.M.F. and the resistance, and the resistance during charging was greater than during discharging in the ratio of 4 to 1. If in one instance the E.M.F. was greater, and in the other the current was less, the result was that the product of the two was precisely the same, and it was quite possible to take out of a battery just as much energy as you put in, and, as a matter of fact, he had taken out 98 per cent. He had omitted to draw attention to one very important improvement which had been introduced by Messrs. Drake and Garham, and that was the operation called "burring" (which he illustrated by a sketch), which prevented the falling out of the pellets from the grid. The question of depreciation could only be solved by actual experience, but his experience of secondary batteries was now very large; he had sent them all over the world, and had received information with regard to their working. The result was that the average life of a positive plate was three years, which of course meant, that whilst some had a shorter life others had a much longer. The negative plate was quite different; he had never seen one which was worn out, or that could not easily be made as good as new. He had heard that day of a Planté battery which was made five or six years ago, and was removed this week, being then in quite good condition. There were fifty-eight cells upstairs which were supplied by the Electric Power Storage Company in January, 1885, and had been in use ever since, and only three sections had been renewed. One had been brought down, and might be examined, but those had been used simply for regulation. On the whole, however, he could not as a practical man recommend any one to estimate the depreciation at less than 15 per cent. per annum.

The CHAIRMAN then proposed a vote of thanks to Mr. Preece. He said, when the history of electric lighting came to be written, it would be found that the papers read before the Society of Arts formed no inconsiderable portion of it, and to that portion Mr. Preece himself had contributed on more than one occasion.

The vote of thanks was carried unanimously, and the meeting adjourned.

CATALOGUE OF THE ART-WORKMANSHIP EXHIBITION.

I.—POTTERY (INCLUDING PORCELAIN AND EARTHENWARE).

The following articles are sent by art workmen in the employ of Messrs. Doulton and Co., Nile-street Works, Burslem, Staffordshire:—

CLASS I.—THE BODY, ANY MATERIAL.

Section A—Thrown, not Shaved.

1. G. T. Scott.
   Nine vases in various sizes and designs.
2. James Hilditch.
   Four vases.
3. F. Watkin.
   Two pairs of vases.

Section B—Shaved or Turned.

4. Frederick Hancock.
   Vase, original design, of Greek spirit, unglazed earthenware, all ornamentation effected on the lathe.
   Pair of vases, original design, in Greek style, unglazed terra-cotta, all ornamentation effected on the lathe.
   Pair of vases, original design, unglazed earthenware, all ornamentation effected on the lathe.
   Jardinière, original design, in Romanesque style, unglazed earthenware, all ornamentation effected on the lathe.
   Pair of vases, original design, in Indian style, unglazed earthenware, all ornamentation effected on the lathe.
5. H. Ford, assisted by W. Millward.
   One pair of fluted vases; one pair of vases, fluted foot; two pair of fluted scent boxes; two pair of biscuit boxes; fluted umbrella stand.
6. R. Kiljour, assisted by W. Millward.
   Large fluted vase; pair of plain vases.
7. H. Trigg, assisted by W. Millward.
   Pair of vases with fluted foot; pair of vases with fluted foot and neck; pair of vases, plain; vase, plain; vase, blue body and fluted pedestal.
8. Rupert Steel, assisted by W. Millward.
   Pair of fluted ewer vases, all parts turned on lathe—the handle and neck in first instance turned on lathe and afterwards cut and shaped; pair of fluted vases; large vase with fluted foot.
9. Joseph Bourne, assisted by W. Millward.
   Plain vase; pair of fluted vases.

CLASS II.—DECORATION.

Section A—Modelled and Glazed.

10. Frederick Hancock.
    Pair of ewers; original design in *renaissance* style, intended to serve as wine jugs.

The following articles are sent by art workmen in the employ of Messrs. Doulton and Co., Albert-embankment, Lambeth, S.W.

CLASS I.—THE BODY, ANY MATERIAL.

Section A—Thrown, not Shaved.

11. Alfred J. Bartlett.
    Two vases, original shapes.
12. James Coggins.
    Vase, finished on wheel.
13. William Askew.
    Two vases, original design.

Section B—Shaved or Turned.

14. A. J. Bartlett.
    Two vases, thrown and turned; original designs.
15. James Coggins.
    Large vase, thrown and turned on wheel.
    Small " " "
16. R. Smith.
    Pair of terra-cotta vases, inlaid; original design and shape. Thrown by W. Askew; lathed by R. Smith.
17. Horace Gardiner.
    Tall terra-cotta vase, made and finished on wheel; original shape.
18. Arthur Kerridge.
    Terra-cotta vase, original shape, made and shaved on wheel.
19. Albert Gough.
    Pair of terra-cotta vases; original shapes. Thrown by W. Askew; lathed by A. Gough.
20. William Askew.
    Two vases, made and turned with drawn handles; original shapes.

CLASS II.—DECORATION.

Section A—Modelled and Glazed.

21. Herbert Ellis.
    Ewer in "Silicon" ware, modelled with Bacchanalian subject; original. Thrown by W. Askew; shaved by G. Martin; designed and modelled by H. Ellis.

Section B—Painted under Glaze.

22. Mary Denley.
    Tall narrow-necked vase; original shape and design. Thrown by W. Askew; lathed by G. Martin; decorated by Mary Denley.
23. Beatrice M. Durtnall.
    Faïence vase, decoration original.
24. Josephine A. Durtnall.
    Faïence vase, shape and decoration original. Thrown by W. Askew; lathed by G. Martin; designed and painted by J. A. Durtnall.
25. Jessie Gandy.
    Vase in "Carrara" ware, partly perforated, carved and slipped; original. Thrown by W. Askew; shaved by G. Martin; designed and decorated under glaze by J. Gandy; overglaze finishing by A. Bentley and E. Smith.
26. Esther Lewis.
    12" painted tile; original design; "Spring."
27. Florence Lewis.
    Faïence vase, decoration original.
28. Isabel Lewis.
    Faïence vase, decoration original. Designed and painted by I. Lewis; background by Emma Harrison.
29. Katharine B. Smallfield.
    Faïence vase, decoration original.
30. Gertrude Smith.
    Faïence vase, coloured body, decoration original.
31. William Rowe.
    Painted tile panels, "Spring" and "Autumn;" original.
32. A. Euphemia Thatcher.
    Faience jar, shape and decoration original. Thrown by W. Askew; shaved by G. Martin; designed and worked by A. E. Thatcher.
33. J. H. McLennan.
    Decorative plaque, "Sunset;" original; decorative tile panel for music-room, original.

Section C—Enamel on the Glaze.

34. Emma Roberts.
    Covered vase, "Carrara" ware, shape and ornament original. Thrown by W. Askew; shaved by G. Martin; designed and decorated by E. Roberts.
35. Elizabeth Shelley.
    Vase in "Carrara" ware, decoration original.
36. Fanny Elliott.
    Vase in "Carrara" ware, decoration original.
37. Celia M. Waters.
    Vase in "Carrara" ware, decoration original.

CLASS II.—DECORATION.

Section A, B, and C—Combined, all or in Part.

38. Florence E. Barlow.

Moulded vase, in "Carrara" ware, modelled in parts and finished in enamel. Model and mould made by Nelson Illingworth; pressed by R. Cox; decorated by F. Barlow; assisted in enamel colouring by E. Woodington and C. Wood.

39. Ada Dennis.

Spill-shaped vase in "Carrara" ware, partly modelled and perforated, with panels of figure painting; original. Thrown by W. Askew; shaved by G. Martin; designed and mostly executed by A. Dennis; borders coloured by C. Waters.

40. Edith D. Lupton.

Vase in "Carrara" ware, carved, modelled, and perforated, glazed, and finished in enamel; original. Thrown by W. Askew; shaved by G. Martin; designed and partly executed by E. D. Lupton; finished by Jessie Hinchliff; enamel colouring by E. Woodington, M. Lilley, and A. Bentley.

Vase in "Carrara" ware, modelled, carved, and perforated, with slip decoration under glaze, finished in enamel overglaze; Thrown by W. Askew; shaved by G. Martin; designed and partly executed by E. D. Lupton; finished by E. Woodington, A. Lacey, C. Wood, F. Dennis, F. Lewis, and M. Price.

41. Mark V. Marshall.

Ewer in "Carrara" ware, modelled and glazed, with enamel overglaze colouring; original. Thrown by W. Askew; shaved by G. Martin; designed and modelled by M. V. Marshall; enamel colouring by E. Woodington, C. Francis, A. Lacey, and M. Price.

Ewer in "Carrara" ware, modelled and decorated underglaze, and finished in enamel overglaze; original. Thrown by W. Askew; shaved by G. Martin; designed, modelled, and slipped by M. V. Marshall; partly modelled by E. Jarrett; enamel colouring by E. Woodington, F. Dennis, C. Francis, and F. Lewis.

Ewer in "Carrara" ware, modelled and glazed, finished in enamel overglaze; original. Thrown by W. Askew; shaved by G. Martin; designed and modelled by M. V. Marshall; partly modelled by E. Jarrett; enamel colouring by E. Rowe.

Vase in "Carrara" ware, moulded and glazed, coloured in enamel; original. Thrown by W. Askew; shaved by G. Martin; designed and partly executed by M. V. Marshall; finished by E. Jarrett; enamel colouring by E. Woodington, C. Wood, and A. Tosen.

Ewer in "Carrara" ware, modelled and glazed, with overglaze enamel colouring; original. Thrown by W. Askew; shaved by G. Martin; designed and partly worked by M. V. Marshall; finished by F. Pope; enamel colouring by C. Francis and A. Tosen.

Jug in "Carrara" ware, carved and perforated, glazed, coloured in enamel over glaze; original. Thrown by W. Askew; shaved by G. Martin; designed and modelled by M. V. Marshall; enamel colouring by E. Woodington, M. Lilley, C. Francis, and F. Lewis.

Vase in "Carrara" ware, modelled and glazed, coloured in enamel; original. Thrown by W. Askew; lathed by G. Martin; designed and partly worked by M. V. Marshall; finished by F. Pope; enamel colouring by E. Woodington, C. Wood, and A. Bentley.

42. L. Russell.

Vase in "Carrara" ware, modelled and slipped under glaze, finished in enamel over glaze; original. Thrown by W. Askew; shaved by G. Martin; designed and worked by L. Russell; enamel colouring by F. Lewis and H. Wilkinson.

43. E. Simmance.

Vase, with handles, in "Carrara" ware, decorated under glaze and finished in enamel. Thrown by W. Askew; shaved by G. Martin; designed and decorated by E. Simmance; enamel colouring by F. Lewis and K. Walker.

Vase, with handles, in "Carrara" ware, carved, perforated, and slipped under glaze, finished in enamel over glaze; original. Thrown by W. Askew; shaved by G. Martin; designed and decorated by E. Simmance; enamel colouring by M. Price and A. Tranter.

Class III.—Stone Salt Glazed Ware.

Section A—Plain, Incised, and Glazed.

44. Harry Barnard.
Wine jar; original shape and design. Thrown by W. Askew; decorated by H. Barnard; subject, Æsop's fable, "The Wind and the Sun."

45. Walter Gandy.
Jar in plain stone ware, incised with seaweed; original. Thrown by W. Askew; shaved by G. Martin; designed and incised by W. Gandy.
Bowl, with inner and outer perforated thickness. Thrown and finished on the wheel from one ball of clay. Thrown by W. Askew; designed by W. Gandy; carved and etched by J. Gandy.

46. William G. Hastings.
Salt glazed vase, with figure frieze and group on lid: with piscatorial decorations and trophies; original. Thrown by W. Askew; shaved by G. Martin; designed and decorated by W. G. Hastings.

47. Ernest Jarrett.
Plain stoneware vase, incised; original. Thrown by W. Askew; shaved by G. Martin; designed and decorated by E. Jarrett.

48. Mark V. Marshall.
Ewer and two beakers, with incised decorations; original. Thrown by W. Askew; designed and decorated by M. V. Marshall.
Tankard and two beakers, carved; original. Thrown by W. Askew; designed and decorated by M. V. Marshall.
Two-handed bottle, incised; original. Thrown by W. Askew; designed and decorated by M. V. Marshall.
Vase, incised, with handles and medallions modelled; original. Thrown by W. Askew; designed and decorated by M. V. Marshall.
Small ewer, incised; original. Thrown by W. Askew; designed and decorated by M. V. Marshall.

49. Arthur Ernest Pearce.
Tankard and two beakers, with incised design; original. Thrown by W. Askew; decorated by A. E. Pearce.

50. Frank Pope.
Vase, carved and incised; original. Thrown by W. Askew; shaved by G. Martin; designed and worked by F. Pope.

51. George Tinworth.
Large stoneware pedestal and tazza, decorated in relief with frieze of boys in procession; original. Thrown by J. Coggins; designed and modelled by G. Tinworth.

52. Frank A. Butler.
Two bowls, squeezed and incised; original. Thrown by W. Askew; designed and decorated by F. A. Butler.

53. William Parker.
Vase, incised; original. Thrown by W. Askew; shaved by G. Martin; designed and worked by W. Parker.

Class III.—Stone Salt Glazed Ware.

Section B—Coloured or otherwise decorated.

54. Hannah B. Barlow.
Bowl, modelled, etched, carved, dotted, and slipped; frieze of animals: original. Thrown by J. Coggins; designed and partly decorated by H. B. Barlow; finished by Alice Budden, E. Burrows, A. Maycock, and A. Smith.
Vase, with etchings of animals. Thrown by W. Askew; shaved by G. Martin; designed, modelled, and etched by H. B. Barlow; finished by A. Hellis, E. Allen, and A. Smith.

55. Harry Barnard.
Vase, with design in scraffitto, relief, *pâte sur pâte*, and colour. Thrown by W. Askew; lathed by G. Martin; decorated by H. Barnard; coloured by M. A. Thompson.
Jug, coloured and decorated, initial letters of designer worked into frieze round the shoulder of the jug; original shape and design. Thrown by W. Askew; decorated by H. Barnard; coloured by M. A. Thompson.

56. Alice Budden.
Vase, modelled handles, squeezed top, incised decorations, coloured; original. Thrown by W. Askew; shaved by G. Martin; designed, decorated, and coloured by A. Budden.

57. Frank A. Butler.
Salad bowl, squeezed, carved ornament, and incised modelled handles; original. Thrown by W. Askew; turned by G. Martin, coloured by M.

A. Thompson; designed by F. A. Butler.

Bowl, modelled, stamped, and squeezed; original. Thrown by W. Askew; decorated by F. A. Butler.

Vase, in conventional design, coloured; original. Thrown by W. Askew; shaved by G. Martin; designed and sketched by F. A. Butler; painted by Rosina Brown.

58. Walter Gandy.

Jar in "Doulton" ware; original. Thrown by W. Askew; lathed by G. Martin; designed by W. Gandy; etched by J. Gandy; coloured by M. A. Thompson.

Double bowl, with inner and outer thickness, thrown and finished on the wheel from one ball of clay; original. Thrown by W. Askew; designed by W. Gandy; carved and etched by J. Gandy; coloured by M. A. Thompson.

59. Nelson Illingworth.

Lamp in "Doulton" ware. Thrown by W. Askew; shaved by G. Martin; designed and modelled by N. Illingworth; painted by M. A. Thompson.

60. William Parker.

Three-handle vase, worked in *repoussé* and incised. Thrown by W. Askew; shaved by G. Martin; designed and worked by W. Parker; coloured by A. Smith and — Tucker.

61. Mark V. Marshall.

Flower vase, incised and coloured. Thrown by W. Askew; designed and etched by M. V. Marshall; coloured by A. Smith.

Ewer in stoneware, incised and modelled; original. Thrown by W. Askew; shaved by G. Martin; designed and decorated by M. V. Marshall; coloured by A. Smith.

Bottle; original. Thrown by W. Askew; designed and incised by M. V. Marshall; coloured by A. Smith.

Ewer, etched and slipped and coloured. original. Thrown by W. Askew; designed and decorated by M. V. Marshall; coloured by R. Brown.

62. Onslow E. Whiting.

Vase in "Doulton" ware, modelled and carved; original shape and design. Thrown by W. Askew; shaved by G. Martin; designed and decorated by O. E. Whiting; coloured by M. Aiken.

63. W. Parker and P. E. Kemp.

Larged modelled jug; decorations embodying the northern mythology; original.

64. E. Simmance.

Covered vase in "Doulton" ware; original. Thrown by W. Askew; shaved by G. Martin; designed and decorated by E. Simmance; coloured by M. A. Thompson.

Covered vase with handles; carved, modelled, and perforated; original. Thrown by W. Askew; lathed by G. Martin; designed and worked by E. Simmance; coloured by A. Smith.

CLASS I.—THE BODY, ANY MATERIAL.

Section A—Thrown, not Shaved.

65. John Hillcoat, 91, Freehold-street, York-road, Leeds.

Two vases.

CLASS II.—DECORATION.

Section B—Painted under Glaze.

66. J. W. Simmill, 49, Queen-street, Tunstall, Staffordshire.

Painted plaque, subject, "The Hay-waggon, Sunset," from a picture by C. Schlesinger.

67. W. W. Evans, Brook-house, Lightmoor, Dawley.

Vase, decorated in Persian style.

STONE CARVING.

68. Josiah Farmer, 22, Francis-place, Naunton-crescent, Cheltenham.

Octagonal capital of a column, in 14th century style of architecture, with thistle foliage ornament.

69. Frederick Nelson, 4, Shute-hill-terrace, Teignmouth, South Devon.

Sicilian marble capital of a column, carved with design, "common objects of the sea-shore;" original.

70. William Vickers, 64, Crofton-road, Camberwell.

Capital of a column, carved with bramble foliage and birds.

71. W. H. H. Davis, Lynn-road, Wisbeach.
Octagonal capital of a column, design—an adaptation of a capital in Bath Abbey.

72. W. H. Fry, Church-street, Charlton Kings, near Cheltenham.
Capital of a column, carved in early English style of architecture.

73. William Clayton, 11, Elam-street, Harold-street, Camberwell, S.E.
Capital of a column; original.

74. Arthur Pain, Ashburnham-road, Clive-vale, Hastings.
Capital of a column, carved with an original design in hazel foliage.

75. Robert Tillotson, Kildwick, Leeds.
Capital of a column, carved with original Gothic design.

76. "Spes," 52, Crawford-street, Camberwell, S.E.
Capital of a column, carved with design of chrysanthemum flowers and foliage and small birds.

WROUGHT-IRON WORK.

77. Charles W. Hancock, 3, Victoria-parade, Gloucester-road, Cheltenham.
Hammered wrought-iron *renaissance* panel, for indoor decoration; original design.

78. Henry Ross, 13, Melton-street, Drummond-street, Hampstead-road, N.W.
Wrought-iron grille, for street door.

79. S. C. Hobbs, 19, Munster-square, N.W.
Wrought-iron grille, for inside window screen or glass-door panel; original design; pilaster in moulded plinth, supporting scroll, foliated pediment with eagles' heads carrying festoons of natural flowers; centre filling in—winged animals rampant, with conventional scroll, foliage, and satyr's head in *repoussé* iron.

80. William Hooks, 1, Kensal-place, Kensal-green, N.W.
Wrought-iron grille, for shop door. Designed by G. F. Henney; made by W. Hooks.
Wrought-iron grille, for vestibule door. Designed by G. F. Henney; made by W. Hooks.

81. E. H. Butland, 12, Walnut-road, Chelston, Torquay.
Wrought-iron grille, for inside window screen.

82. Robinson and Robson, 35A, Belvedere-road, S.E.
Wrought-iron panel. Designed and made by T. Winstanley.

83. G. Snailum, 66, Clarendon-road, Hornsey, N.
Wrought-iron grille, for outside window. Original design.

84. A. W. Elwood, 9, Kennington-park-gardens, S.E.
Pair of wrought-iron grilles, for front door.

85. Barnard, Bishop, and Barnards, Limited, Norfolk Iron Works, Norwich.
Ornamental wrought-iron street door panel, or window screen, of original design from nature, in which the hawthorn, wild rose, and clematis are combined. The centre of the panel is filled with the clematis, the right-hand side with the wild rose, and the left with the hawthorn, both of which latter rising from vases. The whole of the work, including the tendrils, flowers, and vases are entirely hand-forged; no matrix, die, or machine of any kind having been used in its production. Made by Frank Ames.

GOLDSMITH'S AND SILVERSMITH'S WORK.

86. Tom Barker, School of Art, Sheffield.
Silver sugar basin, chased with original design.

General Notes.

Population of Bulgaria.—In 1887, the population of Bulgaria amounted to 3,154,375, or 31 inhabitants to the square kilomètre. The population of the principal communes was distributed as follows:—Philippopolis, 33,412; Sofia, 30,428; Rustchuk, 27,198; Varna, 25,256; Shumla, 23,161; Slivno, 20,893; Zagora, 16,039; Tatar Bazardjik, 15,659; Vidine, 14,772; Plevna, 14,307; Sistov, 12,482; Silistria, 11,414; Tirnova, 11,314; and Kustendjs, 10,689 inhabitants. As regards nationalities, the population of 1887 was composed as follows:—Bulgarians, 2,326,250; Russians, 1,069; Servians, 2,142; Turks, 607,319; Greeks, 58,338; Jews, 23,546; Gypsies, 60,291; Germans, 2,245; French, 544; and 80,074 persons belonging to other nationalities.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings at Eight o'clock:—

MAY 8.—"Origin and Manufacture of Playing Cards." By GEORGE CLULOW, F.R.G.S.

MAY 15.—"The Use of Spirit as an Agent in Prime Movers." By A. F. YARROW.

MAY 22.—"Automatic Selling Machines." By J. G. LORRAIN.

MAY 29.—"The Science of Ventilation as applied to the Interior of Buildings." By D. G. HOEY.

APPLIED ART SECTION.

Tuesday evenings, at Eight o'clock:—

MAY 14.—"Venetian Glass." By DR. SALVIATI. J. HUNGERFORD POLLEN will preside.

INDIAN SECTION.

Friday evenings, at Eight o'clock:—

MAY 24.—"Indian Wheats." By JOHN McDOUGALL. J. M. MACLEAN, M.P., will preside.

CANTOR LECTURES.

The following course of Cantor Lectures will be delivered on Monday evenings at Eight o'clock:—

H. GRAHAM HARRIS, M.Inst.C.E., "Heat Engines other than Steam." Four Lectures.

LECTURE I.—MAY 6.—Introductory—Definition of a heat engine—What is heat—Count Rumford's experiments—Davy's experiments—"Heat a mode of motion"—The big gun the simple heat engine—Conversion of heat into work, and of work into heat—Specific heat—Latent heat—Carnot's doctrine —The ideal heat engine, reversible — and impossible—Absolute zero — Steam-engine as a basis of comparison—Heat units—Joule's equivalent—Available heat—Real efficiency of steam-engine—Other heat engines eliminate boiler—Effects of expansion.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, MAY 6...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. H. Graham Harris, "Heat Engines other than Steam." (Lecture I.)
Royal Institution, Albemarle-street, W., 5 p.m. General Monthly Meeting.
Engineers, Westminster Town Hall, S.W., 7½ p.m. Mr. Perry F. Nursey, "Recent Developments in High Explosives."
Chemical Industry (London Section), Burlington-house, W., 8 p.m. Mr. C. Napier Hake, "Explosives."
British Architects, 9, Conduit-street, W., 8 p.m. Annual Meeting.
Medical, 11, Chandos-street, W., 8½ p.m. Annual Oration.
Victoria Institute, 7, Adelphi-terrace, W.C., 8 p.m.
National Indian Association, Westminster Town-hall, S.W., 4½ p.m. Annual meeting.

TUESDAY, MAY 7...Royal Institution, Albemarle-street, W., 3 p.m Dr. J. P. Richter, "The Italian Renaissance Painters: their Education." (Lecture II.)
Civil Engineers, 25, Great George-street, S.W., 8 p.m. Mr. W. H. Greenwood, "The Treatment of Steel by Hydraulic Pressure, and the Plant Employed for the Purpose."
Pathological, 53, Berners-street, Oxford-street, W., 8½ p.m.
Biblical Archæology, 9, Conduit-street, W., 8 p.m.
Zoological, 11, Hanover-square, W., 8½ p.m. 1. Col. C. Swinhoe, "New Indian Lepidoptera." 2. Rev. O. P. Cambridge, "A New Tree Trap-door Spider from Brazil." 3. Mr. F. E. Beddard, "The Anatomy of *Tapirus terrestris.*" 4. Professor Bardeleben, "Præpollex and Præhallux."

WEDNESDAY, MAY 8...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. George Clulow, "Origin and Manufacture of Playing Cards."
Geological, Burlington-house, W., 8 p.m. 1. Rev Edwin Hill, "The Rocks of Alderney and the Casquets." 2. Dr. A. Geikie, paper by the late Arthur Champernowne, "The Ashprington Volcanic Series of South Devon."
Microscopical, King's College, W.C., 8 p.m. 1. Messrs. C. D. Sherborn and F. Chapman, "Additional note on the Foraminifera of the London Clay." 2. Mr. A. E. Stokes, "New Peritrichous Infusoria from the fresh waters of the United States."
Royal Literary Fund, 10, John-street, Adelphi, W.C., 3 p.m.
Inventors' Institute, 27, Chancery-lane, W.C., 8 p.m.
Cymmrodorion, 27, Chancery-lane, W.C., 8 p.m. Mr. G. Laurence Gomme, "Ancient Terrace Cultivation in Wales and elsewhere."
United Service Institute, Whitehall-yard, S.W. 3 p.m. Col. R. Ellis, "Lancers and Lances."

THURSDAY, MAY 9...Royal, Burlington-house, W., 4½ p.m.
Antiquaries, Burlington-house, W., 8½ p.m.
Society for the Encouragement of Fine Arts, 9, Conduit-street, W., 8 p.m. Dr. Phené, "Art Sketches in Travel to the East."
Royal Institution, Albemarle-street, W., 3 p.m. Mr. E. Muybridge, "The Science of Animal Locomotion in its Relation to Design in Art." (Lecture II.)
Electrical Engineers, 25, Great George-street, S.W., 8 p.m. Discussion on Dr. Oliver J. Lodge's paper, "Lightning, Lightning Conductors, and Lightning Protectors."
Mathematical, 22, Albemarle-street, W., 8 p.m.

FRIDAY, MAY 10...United Service Inst., Whitehall-yard, 3 p.m. Colonel A. B. Tulloch, "Battle Training of Regimental Officers."
Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting, 9 p.m. Prof. Dewar, "Optical Properties of Oxygen and Ozone."
Astronomical, Burlington-house, W., 8 p.m.
Quekett Microscopical Club, University College, W.C., 8 p.m.
Clinical, 53, Berners-street, W., 8½ p.m.
Browning, University College, W.C., 8 p.m. Paper by Mr. Frank Marshall.

SATURDAY, MAY 11...Physical, Science Schools, South Kensington, S.W., 3 p.m. Prof. O. J. Lodge, 1. "An Electrostatic Field, prodnced by Varying Magnetic Induction." 2. "The Concentration of Electro-magnetic Waves by large Cylindrical Lenses."
Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m.
Royal Institution, Albemarle-street, W., 3 p.m. Mr. J. Bennett "The Origin and Development of Opera in England." (Lecture II.)

Journal of the Society of Arts.

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FRIDAY, MAY 10, 1889.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

MOTOR TRIALS.

The report of the Society of Arts' Motor Trials has been reprinted as a pamphlet, with the addition of Prof. A. B. W. Kennedy's paper on "The Objects and Methods of the Society of Arts' Motor Trials." The pamphlet (price one shilling) can be obtained on application to the Secretary.

CANTOR LECTURES.

Mr. H. Graham Harris, M.Inst.C.E., delivered the first of his course on "Heat Engines other than Steam," on Monday evening, May 6th.

The lectures will be published in the *Journal* during the summer recess.

ART-WORKMANSHIP COMPETITION, 1889.

The judges appointed by the Council of the Society of Arts have awarded the following prizes for objects submitted in the above Competition:—

POTTERY.

Class I.—The Body, any Material.

Section A—Thrown, not shaved.

First Prize (£5) to G. T. Scott, of Doulton and Co., Burslem, for nine vases in various shapes and sizes.

Second Prize (£2) to W. Askew, of Doulton and Co., Lambeth, for a vase of original design, marked "114A."

Section B—Shaved and Turned.

First Prize (£5) to H. Ford, assisted by W. Milward, of Doulton and Co., Burslem, for a pair of fluted vases; a pair of vases, fluted feet; two pairs of fluted scent boxes; a pair of biscuit boxes; fluted umbrella stand; and a *pot pourri*, marked "Emerson," for which special commendation is given.

Second Prize (£2) to Rupert Steel, assisted by W. Millward, of Doulton and Co., Burslem, for a pair of fluted ewer vases, all parts turned on lathe—the handle and neck in first instance turned on lathe and afterwards cut and shaped; a pair of fluted vases; a large vase with fluted foot.

An additional Second Prize (£2) to H. Trigg, of Doulton and Co., Burslem, for a pair of vases with fluted feet; a pair of vases with fluted feet and necks; a pair of vases, plain; a vase, plain; a vase, blue body and fluted pedestal.

Honourable mention "for skill in shaving" to A. J. Bartlett, of Doulton and Co., Lambeth, for a vase marked "103."

Class II.—Decoration.

Section A.—Modelled and Glazed.

First Prize (£10) to Herbert Ellis, of Doulton and Co., Lambeth, for a ewer in "silicon" ware, modelled with Bacchanalian subject; original. Thrown by W. Askew; shaved by G. Martin; designed and modelled by H. Ellis.

Section B.—Painted under Glaze.

First Prize (£10) to Mary Denley, of Doulton and Co., Lambeth, for a tall narrow-necked vase; original shape and design. Thrown by W. Askew; lathed by G. Martin; decorated by Mary Denley.

Section C—Enamel on the Glaze.

First Prize (£10) to Ada Dennis, of Doulton and Co., Lambeth, for a spill-shaped vase in "Carrara" ware, partly modelled and perforated, with panels of figure painting; original. Thrown by W. Askew; shaved by G. Martin; designed and mostly executed by A. Dennis; borders coloured by C. Waters. Awarded for panel paintings only.

Third Prize (£3) to L. Russell, of Doulton and Co., Lambeth, for a vase in "Carrara" ware, modelled and slipped under glaze,

finished in enamel over glaze; original. Thrown by W. Askew; shaved by G. Martin; designed and worked by L. Russell; enamel colouring by F. Lewis and H. Wilkinson.

Class III.—Stone Salt Glazed Ware.

Section A—Plain, Incised, and Glazed.

First Prize (£10) to Ernest Jarrett, of Doulton and Co., Lambeth, for a plain stoneware vase, incised; original. Thrown by W. Askew; shaved by G. Martin; designed and decorated by E. Jarrett.

Second Prize (£5) to Frank Pope, for a vase, carved and incised; original. Thrown by W. Askew; shaved by G. Martin; designed and worked by F. Pope.

Third Prize (£3) to Frank A. Butler, for two bowls, squeezed and incised; original. Thrown by Thomas Askew; designed and decorated by F. A. Butler.

Honourable Mention.

Harry Barnard, of Doulton and Co., Lambeth, for a wine jar; original shape and design. Thrown by W. Askew; decorated by H. Barnard; subject, Æsop's fable, "The Wind and the Sun."

Walter Gandy, of Doulton and Co., Lambeth, for a jar in plain stone ware, incised with seaweed; original. Thrown by W. Askew; shaved by G. Martin; designed and incised by W. Gandy.

Arthur Ernest Pearce, of Doulton and Co., Lambeth, for a tankard and two beakers, with incised design; original. Thrown by W. Askew; decorated by A. E. Pearce.

Section B.—Coloured or otherwise Decorated.

First prize (£10) to Hannah B. Barlow, of Doulton and Co., Lambeth, for a bowl, modelled, etched, carved, dotted, and slipped; frieze of animals; original. Thrown by J. Coggins; designed and partly decorated by H. B. Barlow; finished by Alice Budden, E. Burrows, A. Maycock, and A. Smith. For a vase, with etchings of animals. Thrown by W. Askew; shaved by G. Martin; designed, modelled, and etched by H. B. Barlow; finished by A. Hellis, E. Allen, and A. Smith.

An Additional First Prize (£10) to William G. Hastings, of Doulton and Co., Lambeth, for a salt glazed vase, with figure frieze and group on lid: with piscatorial decorations and trophies; original. Thrown by W. Askew; shaved by G. Martin; designed and decorated by W. G. Hastings.

Second prize (£5) to Frank A. Butler, of Doulton and Co., Lambeth, for a salad bowl, squeezed, carved ornament, and incised modelled handles; original. Thrown by W. Askew; turned by G. Martin; coloured by M. A. Thomson; designed by F. A. Butler.

Third Prize (£3) to Walter Gandy, of Doulton and Co., Lambeth, for a jar in plain stone ware incised with seaweed; original. Thrown by W. Askew; shaved by G. Martin; designed and incised by W. Gandy. For a bowl, with inner and outer perforated thickness. Thrown and finished on the wheel from one ball of clay. Thrown by W. Askew; designed by W. Gandy; carved and etched by J. Gandy.

Honourable Mention.

Harry Barnard, of Doulton and Co., Lambeth, for a jug, coloured and decorated, initial letters of designer worked into frieze round the shoulder of the jug; original shape and design. Thrown by W. Askew; decorated by H. Barnard; coloured by M. A. Thompson.

STONE CARVING.

Second Prize (£15) to W. H. Fry, Church-street, Charlton-kings, Cheltenham, for a capital of a column; carved in the early English style of architecture.

Second Prize (£15) to Josiah Farmer, 22, Francis-place, Naunton-crescent, Cheltenham, for an octagonal capital of a column, carved in 15th century style of architecture, with thistle foliage ornament.

Third Prize (£10) to William Vickers, 64, Crofton-road, Camberwell, for a capital of a column, carved with bramble foliage and birds.

Fourth Prize (£5) to Frederick Nelson, 4, Shute-hill-terrace, Teignmouth, South Devon, for a Sicilian marble capital of column. Carved with a design, "Common Objects of the Seashore."

WROUGHT-IRON WORK.

First Prize (£25) to S. C. Hobbs, 19, Munster-square, N.W., for a wrought-iron grille for inside window screen or glass door-panel.

Second Prize (£15) to William Hooks, 1, Kensal-place, Kensal-green, N.W., for a

wrought-iron grille for vestibule door. Designed by G. F. Henney.

Third Prize (£5) to Henry Ross, 13, Melton-street, Drummond-street, N.W., for a wrought-iron grille for a street door.

The whole of the work sent in for competition in this class is highly commended.

GOLDSMITH'S AND SILVERSMITH'S WORK.

Second Prize (£5) to Tom Barker, School of Arts, Sheffield, for a silver sugar basin, chased with original designs.

Proceedings of the Society.

INDIAN SECTION.

Friday, May 3, 1889; SIR LEPEL GRIFFIN, K.C.S.I., in the chair.

The CHAIRMAN, in introducing the reader of the paper, remarked that in that place political questions were discouraged, if not absolutely forbidden, but in the case of Eastern countries politics and trade were indissolubly connected, and it was an undoubted fact that trade followed the flag. England held up the light of free trade, but many other countries still relied on protection. England wished only for a fair field and no favour, but the basis of Russian policy in Central Asia was that wherever her flag flew the door was shut to the commerce of all other nations, except under such differential duties as were almost prohibitive. Where England bore sway she allowed every one a full and free chance, encouraged no doubt by the conviction that the larger part of the trade would fall into her own hands. This had been the case with the Suez Canal, and no doubt would be so with the Karún River, which His Highness the Shah of Persia, influenced by our enlightened and energetic Minister, Sir Henry Drummond Wolff, had now opened to the world. This river penetrated about 200 miles into the heart of Persia, and would open up a large field for English commerce. He hoped that when the Shah visited England the Chambers of Commerce would in some public way testify their sense of his enlightened policy in taking this step, which he was quite sure would be as much for the benefit of Persia as of England.

The paper read was—

THE KARUN RIVER AS A TRADE ROUTE.

By MAJOR-GEN. SIR R. MURDOCH SMITH, K.C.M.G., Royal Engineers.

The Karún is one of the branches of the great river system which constituted the principal physical feature, and the main physical means of support, of the mighty empires of antiquity—the Babylonian, the Assyrian, the Medo-Persian, the Greek, the Parthian, and the Sassanian. One empire succeeded the other, but each in turn had its nucleus or centre of gravity in the thickly peopled plains which were watered by the great river system of which the Karún forms an important component part. Empire passed from one dynasty and one nation to another, but its seat and centre never left the populous banks of the great rivers which converge on the head of the Persian Gulf, in the estuary now known as the Shat-el-Arab. Even after the overthrow of the Sassanian kingdom of Persia by the Arabs, the eastern world was long ruled from the banks of the Tigris by the Abbasid Khalifs of Baghdad. Babylon, Nineveh, Susa, Seleucia, Ctesiphon, have all passed away; even Baghdad and Bussorah, which in the early years of Islam took in some degree the place of those ancient seats of empire, are now but the shadows of their former selves. Still the physical conditions are now exactly what they were in the days of Semiramis, Darius, and Harún-er-Rashid. The great alluvial plains of Mesopotamia and Khuzistan are just as fertile, and the rivers by which they are watered—the Euphrates, the Tigris, the Diala, the Kerkhah, and the Karún—just as copious as they ever were. It is hardly possible to believe therefore that a region so richly endowed by nature, and for so many centuries the very centre of power and civilisation, should remain for ever in its present condition. Signs of an awakening to a sense of its great possibilities are not wanting, among which the opening of the Karún to navigation is not the least hopeful. In the East, however, movement is proverbially slow, especially if in an upward or forward direction. We must, consequently, not expect to see all difficulties immediately removed, and a new era of prosperity at once inaugurated.

With these preliminary remarks, suggested as they are by the very names of the regions to which they refer, I shall now endeavour to point out what immediate commercial benefits the opening of the Karún is capable of afford-

ing, and how, in my opinion, those benefits may most readily and practically be obtained.

The first consideration that presents itself regarding the Karún is the fact that, from its source to its mouth, it is a purely Persian river. There is thus no complication of interests arising from partial or joint sovereignty. Until it reaches the tidal estuary of the Shat-el-Arab, which forms the boundary between Turkey and Persia, and is a water highway common to both countries, the Karún lies entirely within the Shah's dominions, of which it is, in fact, the only navigable river. The Euphrates and Tigris, on the other hand, flow throughout their course through Turkish territory. Persia's claim to both banks of the Karún down to the Shat-el-Arab was for many years challenged by Turkey on the ground that the present bed of the river, near its mouth, was not the original one. This contention, however, was over-ruled, and Persia's claim to the whole course of the river established by arbitration nearly fifty years ago. The opening or closing of the river to navigation is consequently a question of purely domestic Persian policy, entirely within the Shah's prerogative, and not dependent, like the navigation of the Danube, for instance, on international agreement. This fact, although essentially a political one, must be borne in mind in considering the commercial aspects of the Karún, with which alone we are now concerned.

Owing to the nature of our climate, we are in the habit in this country of regarding a river, from a utilitarian point of view, as a natural drain for carrying off superfluous water rather than as a means of supplying that great necessary of life. In the extremely dry climate of Persia the reverse holds good. It is as a means of water supply and irrigation, rather than as a drain, that a river is there regarded. The other great practical use to which rivers are put in the East, as in the West, is as highways for navigation. From a commercial point of view this latter consideration is naturally the most prominent, if not the most important. It should not, however, be taken too exclusively into account. In the case of the Karún, the Tigris, the Euphrates, and the other branches of the same great river system, their capabilities in respect of irrigation are of even greater ultimate importance than their more immediate adaptability to the requirements of navigation. It is, however, this latter aspect of the subject with which, while not forgetting the other, we are now more especially concerned.

Regarded, therefore, simply as a navigable highway and means of communication, let us first see what kind of a highway the Karún is, or is capable of becoming, and then glance at the regions to which it leads, and the resources which its opening may help to develop.

As a highway, the Karún may be said to begin at the town of Shushter, whence, having already issued from the mountains, it flows in a generally placid course across the great alluvial plain of Ram Hormuz towards the head of the Persian Gulf. Shushter (probably Shah Shatra, or City of the King) was founded, or at all events greatly added to, by Shapur, the conqueror of the Roman Emperor Valerian, whose captured treasure he expended in erecting, about the year A.D. 260, the great engineering works by which the waters of the Karún at Shushter are still controlled. In a recent communication to the Bombay branch of the Royal Asiatic Society, Mr. Jeevanjee Jamshedjee Modi quotes an interesting passage from the "Shahnameh," in which Ferdousi, the great Persian epic poet of the 10th century, describes the building of the bridge and dam at Shushter by Baránush (Varanus), a Roman prisoner taken at the battle of Edessa, to whom Shapur promised his freedom as a reward for the successful application of his engineering skill. By means of a dam at Shushter, called the Band-i-Mizan, a few yards above the bridge and *band* of Baránush, which are still standing, the waters of the Karún are partially diverted to the left into an artificial navigable canal called the *Ab-i-Gargar*. Thirty-two miles below Shushter the canal rejoins the main branch of the Karún at Bend-i-Kir, where also it is joined by the partly navigable affluent of the Diz or Dizful river, which passes the large town of Dizful nearly 70 miles above the confluence. Between Shushter and Bend-i-Kir, the Ab-i-Gargar canal, which has evidently been constructed for navigation as well as irrigation, is still well suited for the former purpose. Native boats are used on it to some extent at the present day. Throughout the year there is a sufficient depth of water for the free passage of suitable river steamers. Unlike such rivers as the Indus, whose shifting channels greatly impede the navigation, the bed of the Ab-i-Gargar, and, in fact, of the whole course of the Karún, is well-defined and permanent. At Ahwaz, 24 miles below Bend-i-Kir—that is to say,

56 miles from Shushter—we come to the only obstruction to navigation that exists between Shushter and the sea. The obstruction is caused by a low ridge of sandstone rocks, over and through which the river flows in a short series of rapids, with a total fall of about 8 feet or 10 feet. The water in former days was, at this point, still further dammed or pent up for irrigation purposes by a massive masonry *band*, portions of which are still standing. Ahwaz, now an insignificant village on a slight elevation on the left bank of the river close to the band, was, until its destruction in the 13th century, a large and important city. The Ahwaz rapids, although actually passed by the S.S. *Assyria* during the flood season of 1842, form what is practically an impassable bar to the navigation. They could, however, be easily turned by a short inexpensive canal little more than a mile in length. The detailed report of Major Wells, R.E., who carefully examined the rapids at my request in 1881, is published in the "Proceedings of the Royal Geographical Society" for March, 1883.

From Ahwaz to Mohammerah, a distance of 81 miles, the Karún is throughout easily navigable by river steamers. A mile below Mohammerah, it enters the Shat-el-Arab about 40 miles from the sea. The Shat-el-Arab is navigable for ocean-going vessels drawing 19 feet of water. The Karún, therefore, in connection with its estuary, considered as a highway and means of communication, consists of three parts, viz., the Shat-el-Arab portion, 40 miles in length; the lower Karún, 81 miles; and the Ab-i-Gargar 56 miles, or a total from Shushter to the sea of 177 miles. Cargoes must be transhipped at Ahwaz on account of the rapids, and at Mohammerah from river to ocean steamers, or *vice versâ*. At Mohammerah the transhipment is easily effected, as the two steamers can lie alongside of each other. At Ahwaz, cargoes must be carried a few hundred yards.

From this short description it is quite clear that what the Karún wants to make it thoroughly efficient and convenient as a water highway is a short canal with the necessary locks at Ahwaz.

Let us now glance for a moment at the regions towards which the highway we have just been considering leads, and see how it is likely to affect their commerce.

First of all, it leads directly to the fertile lands in the neighbourhood of Shushter and Dizful, which produce crops of wheat, barley, and indigo, capable of being increased to an indefinite extent. With regular communication by means of river steamers between Shushter and Mohammerah, a great incentive would be given to increased activity in the agriculture of those districts, and gradually to the cultivation of extensive areas now absolutely deserted. The plains within easy distance of Shushter and Dizful are the winter and spring quarters of several large nomadic tribes or Eeliauts, the produce of whose numerous flocks, such as butter, wool, and hides, would by means of the Karún navigation be brought within easy reach of the markets of India and Europe. Once an impetus was given, the gradual resuscitation of this naturally rich and formerly populous province could hardly fail to follow. When one sees the amount of labour and money so often expended in Persia to but little purpose in bringing scanty supplies of brackish water to irrigate patches of poor soil, one feels that the resources of the Karún plains have only to get a start to attract an industrious population from other less favoured parts of the country. One great inducement would be the excellence of the water for drinking purposes, as well as its abundance for irrigation. A very full and interesting description, not only of the Karún, but of the whole province of Khuzistan, is given by Sir Henry Layard in vol. xvi. (1846) of the "Journal of the Royal Geographical Society."

Immediately to the north-east of the plains of Shushter and Dizful, and lying between them and the central plateau on which the chief cities of Persia are situated, comes a belt of rugged mountainous country which must be passed before the upper plains are reached, at an average elevation of 4,000 to 5,000 feet above the level of the sea. The same difficulty of a long, steep ascent presents itself wherever the plateau is approached from the lower plains, a difficulty which there is no possible means of avoiding. In this belt of mountains the Eeliauts who encamp in the plains of Shushter and Dizful in the winter have their summer quarters. There is abundance of excellent pasture and water for their flocks, but almost no cultivation. There is, however, a zone of fine forest trees, such as beeches, planes, and oaks, from which products suitable for export could no doubt be obtained.

Immediately beyond this barrier belt of mountains lie some of the principal provinces of Persia, such as Ispahan, Irák, Meláyer, Hamadan, Kermanshah, and Kurdistan. In all of these provinces inter-communication is

comparatively easy once the barrier is crossed, and the general level of the great plateau on which they are situated is attained. They enjoy a remarkably fine climate and fertile soil, and, compared with other parts of Persia, are well watered. Fruit of many kinds, of excellent quality, suitable for drying and exporting, is cheap and abundant. Good wine is made by the Armenians at Ispahan and Hamadan, which might gradually be developed into an article of export by any one practically acquainted with the trade, and with all the processes connected with wine-making. Care would of course have to be taken so to conduct operations as not to offend the religious prejudices of the Persians, to whom, as Mussulmans, wine is forbidden. Cotton and tobacco grow freely, and wheat and barley are everywhere abundant. Opium and rice are extensively cultivated in the province of Ispahan. Irák and Kurdistan are the principal seats of the carpet-weaving industry of Persia. In the former the larger kind of carpets called *kâli* are chiefly made, while Kurdistan is famous throughout the East for its remarkably delicate and beautiful *kâlichehs* or rugs.

At present the trade in Persian carpets is greatly restricted by the long and therefore expensive land transport between the districts where they are woven and the sea, and still more by the difficulty in getting carpets of the exact sizes required by individual purchasers in Europe. With a good system established whereby they could be ordered of any particular size, colour, and design, and obtained without undue delay, there is no doubt that those beautiful products of the Persian looms would soon become an important item in the foreign trade of the country.

Their resources for export trade purposes may be enumerated as follows in the order of their probable importance :—Wheat, wool, cotton, opium, dried fruits, hides, butter, tobacco, tanning and dye stuffs, and vegetable oils, in addition to carpets, rugs, and perhaps wines.

The chief imports are cotton goods of all kinds, woollen cloth, furs, tea, sugar, candles, copper sheets, zinc, iron bars, cutlery, hardware, glass and glassware, pottery, paraffin oil, stationery, and fancy articles.

The importance of the Karún route as a means of developing the export and import foreign trade of Persia, depends chiefly on the abridgment which it may effect in the distances to be traversed by the present primitive method of pack transport between the principal trade centres and the sea. Vehicular traffic does not exist, nor is the country in many places at all well suited for its introduction. This is particularly the case in the belt of mountains already referred to as everywhere surrounding the upper plateau, and lying between it and the lower plains, such as the valley of the Karún. A maximum camel load may be taken as 450 lbs., a mule load as 300 lbs., and an ass load as 120 lbs. For those different means of transport, therefore, no package must exceed half those weights respectively. With such primitive means of carriage it is evident that although good animals are abundant, the land transport of merchandise must be very expensive, so much so, in fact, as to be altogether prohibitive in the case of cheap bulky materials, except for very short distances. But even in the case of more valuable articles the cost of carriage at present stands in an inordinately high proportion to the cost of production. Every mile therefore of land carriage that can be saved is an appreciable gain to the commerce of the country.

To estimate the gain in this respect which the Karún route is capable of affording, it is necessary to compare it with the existing routes between those provinces which its navigation may affect and the sea. Many districts may clearly be eliminated from this comparison, as they lie altogether beyond the sphere of the Karún. Kerman and South-Eastern Persia generally must continue to carry on their foreign trade through the port of Bunder Abbas. Fars, including its capital, Shiraz, will similarly continue to trade exclusively with Bushire. Ghilan, Mazanderan, Asterabad, and part of Khorasan, must necessarily confine their trade to the Caspian ports, and therefore to Russia, with which country those ports are in direct steam communication. Azerbaijan, with its capital, Tabreez, will continue to conduct its foreign trade, partly through Erzeroum and Trebizond, and partly through the Caucasus. Probably the foreign trade of Kermanshah will continue to pass, as it does now, by way of Baghdad and the Tigris. There is, therefore, almost a complete circle of provinces on the western, northern, eastern, and southern frontiers of Persia, whose trade will be little if at all affected by the opening up of the Karún river. There remains, however, nearly the whole of Central and South-Western Persia, where the effect of a new opening by way of

the Karún may be expected to be very considerable. In this region the principal cities and trade centres are Teheran, Ispahan, Kashan, Koom, Hamadan, Sultanabad, Dowletabad, Burujird, Shushter, Dizful, and Mohammerah.

Teheran, the capital, is a city of at least 120,000 inhabitants, where much of the wealth of the country is accumulated, and where a good deal of it is spent on European manufactures of all kinds. The bazaars, which are spacious and well built, are always crowded, and show every sign of great commercial activity. English cotton goods, which formerly monopolised the market, still predominate, although those of Russian origin have of late years made great way. Woollen cloth comes chiefly from Austria, while Russia has practically the whole trade in sugar, candles, pottery, brasswork, and hardware generally. The gradual supercession of English by Russian manufactures, which has been going on for some years in Teheran, is due to the great impetus given to the foreign trade of Russia by the extension of her railways, and still more, so far as Persia is concerned, by the enormous development of steam navigation on the Caspian, consequent on the application of petroleum residuum as fuel for steamers. Coal was so dear that it was only by dint of heavy State subsidies that steam navigation could be maintained on the Caspian at all. Now, the *astatki*, or petroleum fuel, costs a mere trifle, and stokers are no longer required. Russian imports reach the Teheran bazaars entirely by way of the Caspian, chiefly through the port of Euzelli, 230 miles distant, and partly through Meshed-i-Sar, to which the distance is only 120 miles. English imports come either from Trebizond or Bushire, distant 1,000 miles and 800 miles respectively. By the Karún route the land carriage to Teheran would be reduced to 485 miles, a difference which would probably suffice to turn the scale in favour of English goods, or at least enable them to continue successfully the present competition.

Ispahan, formerly the capital of Persia, and now containing about 80,000 inhabitants, is of great commercial importance. It is situated in the very heart of the country in a rich, fertile, well-watered district. Its distance from Bushire is 520 miles, while from Shushter it is only 260. Kashan, with about 20,000 inhabitants, where there is a considerable industry in silk, is 640 miles from Bushire, and 380 from Shushter. Koom, a holy city and place of pilgrimage, with cobalt mines in the neighbourhood, and a considerable manufacture of pottery, is 700 miles from Bushire, and 400 from Shushter. Hamadan, situated at the base of Elwand, in an unusually well-watered district, in which fruit grows in great profusion, is 320 miles from the Turkish river-port Baghdad, and 260 from Shushter. Sultanabad, the centre of the carpet-weaving industry, is 700 miles from Bushire, and 320 from Shushter. Burujird, a thriving town of about 20,000 inhabitants, is the seat of government of a large and fertile district. It occupies a peculiarly central position on the plateau of Persia, with comparatively good and easy roads to Hamadan, distant 90 miles, Kermanshah 130 miles, Ispahan and Teheran each 230 miles. It is thus peculiarly well adapted to become an important trade centre. Its distance from Baghdad (which it must be remembered is not a Persian but a Turkish port), is 350 miles, and from Shushter 250. In regard to this very central position for commercial purposes there is therefore a difference of 100 miles in favour of the Karún route as compared with the Tigris one, besides the further great advantage that on the Karún route foreign custom-houses do not intervene as they do on the Tigris, one between Burujird and the sea.

We may therefore sum up the commercial advantages of the Karún navigation as follows:—A great part of Central Persia, including some of its richest provinces, may by its means be brought some 200 or 300 miles nearer to ship transport than they are at present. Means will thus be afforded of exporting many products of the country which, owing to the prohibitive cost of land transport, it is now impossible to export, and which therefore there is now no sufficient incentive to develop. A corresponding impetus will similarly be given to the import trade of those provinces. The growing commercial monopoly of Russia in the north, due to her command of all the outlets in that direction, with the single exception of the inconvenient and tedious route by Erzeroum and Trebizond, will be checked, and a fair field maintained for other competitors. A gradual revival of the former prosperity of Khuzistan, through the opening up of the Karún country, is perhaps not to be despaired of.

As to the means by which these advantages are to be attained, I shall first consider them from a Persian and then from an English or European point of view. As regards Persia, the first step has already been taken in the opening up of the lower Karún to foreign

steam navigation. The next step should undoubtedly be the enforcement by the Persian Government of a certain amount of law and order among the nomadic tribes who inhabit the mountainous country immediately north and east of Shushter and Dizful, and lying, as I have already remarked, between those towns and the central plateau of Persia. Across this mountainous belt two roads lead direct from Shushter to Ispahan through the country of the Bakhtiyari, while another, a much more practicable one, leads *viâ* Dizful through the country of the Feili Lurs to Khorremabad and Burujird. This latter is much the most important, not only because it is the most practicable route between the upper and the lower plains, but also because it is the direct road to Kermanshah, Kurdistan, Hamadan, Melayer, Sultanabad, Koom, and Teheran. North of Khorremabad the roads are safe enough, but steps must be taken by the Persian Government for the security of the 150 miles of road between that place and Dizful if it is ever to become a regular trade route.

The third step to be taken by the Persian authorities should, I think, be the re-establishment of the telegraph, and of the *chapar*, or horse-post, which at one time existed along this road. Of course, in the Khorremabad-Dizful section this step could only be taken to any good purpose, *pari passu*, with step No. 2. From Khorremabad northwards, the telegraph is, I believe, still in operation, *viâ* Hamadan, but I am not aware whether it is in working order between Dizful, Shushter, and Mohammerah. If not, it should certainly be restored. The *chapar*, or horse-post, an admirable means of rapid locomotion, established for many centuries along all the main roads radiating from the capital to the frontiers, should be re-established along those parts of the Shushter-Dizful-Burujird road in which it has fallen into disuse.

Fourthly, the present mule track between Shushter and Burujird should be made, if not into a carriageable, at least into a good pack road, fit for the passage of *takhteravans*, or mule litters. This could be easily done at very little expense.

Fifthly and lastly, a short canal should be made round the rapids at Ahwaz, and the Karún be thereby opened to uninterrupted steam navigation the whole way to Shushter by the Ab-i-Gargar, and possibly to Dizful also, by the Diz. It is clear from Major Wells' report that such a canal could be made without difficulty at no great cost. The length need be little over 2,000 yards, and the average depth of cutting through loose soil and sandstone only about 20 feet. A single lock would suffice.

While the above measures ought undoubtedly to be immediately undertaken in its own interest by the Persian Government, I think it would be a great mistake, from the English or European point of view, for us to sit still and do nothing until they were fully accomplished. The opening of the lower Karún to foreign steam navigation is not only a patriotic measure on the part of the Shah, with the object of developing the resources and adding to the wealth of his country, but it is at the same an earnest of his Majesty's desire to meet the wishes of such friendly countries as have commercial interests in Persia. Instead, therefore, of simply waiting for further facilities being provided, it is, I think, incumbent on us, whose only free access to the markets of Persia is by way of the Persian Gulf, to do what we can towards utilising the facilities already offered. By this means we shall best encourage the Persian Government to take the further steps which I have already indicated.

I am glad to hear that the steamers of the Tigris Navigation Company have already begun to navigate the Karún between Mohammerah and Ahwaz. They should, I think, be supplemented by a service of native boats or steam launches, between Ahwaz and Shushter. The service, both of boats and steamers, should be regular in connection with the weekly mail steamers, between Bussorah and Bombay, which pass up and down the Shat-el-Arab, close to Mohammerah. A postal service and regular means of communication along the Karún would thus be established, for which a substantial subvention might very properly be granted by the Imperial or Indian Government. Such a service is indispensable to the organisation of a new trade route, and its establishment should not be deferred until other supplementary measures have been taken by the Persian Government.

Much will of course depend on the judgment of the merchants who first take the Karún route in hand, and on the tact of their agents at Shushter, Dizful, Burujird, and Ispahan, from which points they will be able to enter into friendly relations with the chiefs of the Eeliaut tribes, whose goodwill and co-operation it will be of the utmost importance to secure. This is in fact the crucial point of the whole question. Unless the Eeliauts are either coerced or conciliated into good be-

haviour, trade on a large scale between the Karún and the central plateau of Persia will be impossible. The conciliation will depend chiefly on the European merchants and their agents on the spot. Coercion, when necessary, can of course only be applied by the Persian Government. There will certainly be considerable difficulties for some time to come, but there is no reason to doubt that the Lur chiefs will, in their own interest, eventually secure the safe passage of caravans through their country. With a combination of tact on the part of the merchants, and firmness on the part of the Persian governors, this happy result need not be slow of attainment.

Altogether, the prospects are hopeful. The opening of the Karún to our steamers shows that the feeling of suspicion with which our motives and actions were so long regarded, is at last yielding to one of confidence in our good faith. This change of sentiment is, I have no doubt, largely due to the experience which the Persians of all classes have had of us, and we of them, during the last twenty-five years of mutual friendship and good offices in the telegraph department. During this long experience the Shah and his ministers have gradually seen for themselves that, although occasions were seldom wanting, our officers and *employés* religiously refrained from the slightest interference in local affairs, and habitually took every opportunity of rendering to the Persian authorities such services as lay in their power.

As another sign of the spirit of progress, I may mention the recent establishment, with the Shah's sanction, of branches of two English banks in Teheran and other Persian towns, a measure which will greatly facilitate commercial operations, and lead to the gradual introduction of European capital into the country.

Unless I am greatly misinformed, a serious attempt on a large scale, by means of a concession to a great European capitalist, is about to be made towards the development of the mineral resources of the kingdom.

These and other progressive measures which might be mentioned are not the outcome of a sudden caprice on the part of the Shah, but are due to a deliberate conviction, very slowly arrived at, that they are safe and well calculated to benefit his country. They are thus all the more likely to prove of permanent value.

Of railways I have purposely said nothing, but have confined my remarks to the more immediate advantages of the new trade route, towards the establishment of which the opening up of the Karún is the first great step. On the manner in which that measure is utilised and supplemented will chiefly depend the chances not only of railways, but of all other means of developing the resources and increasing the prosperity of what ought to be a great, as it certainly is a most interesting, and to us a very friendly, country.

DISCUSSION.

Professor VAMBERY said he had listened with great attention to this paper, which was full of highly interesting details, and was perhaps the best paper hitherto published on the subject. The wealth of the Karún district was known in ancient times, and in the days of Harun-el-Rashid and the Mohammedan caliphate, the province of Khuzistan produced an annual revenue to the State of 22,000,000 francs. Ahwaz was then very famous for its carpets, especially a particularly fine description made of silk; and Hussein, an Arab poet, in praising the object of his affections, said her cheeks were as fine and smooth as an Ahwaz carpet. Besides these carpets, the province was rich in many other products, which were exported to the Far East as well as to the West, and he could therefore thoroughly agree with what had been said as to the probable future development of the country. He could not, however, agree in everything which had been advanced. He was not sanguine enough to think that his English friends would profit very much by this new route if what was reported about Russia were correct. He had been much delighted when he first heard of the English concession, but those which were said to have been given to Russia would entirely neutralise the advantage. The Czar had the oyster and England the shell, and though the shell might be better than nothing, and if well worked might produce something, the gain would be but small. Trade in Persia was closely connected with pilgrimages; they had a proverb—"A little pilgrimage and a little business." One object of these pilgrimages was Meshed, to the tomb of a very famous saint, and another was to Kerbela, near Bagdad; and the two titles which were very highly cherished in Persia were *Meshdi* and *Kerbelai*, signifying those who had made these pilgrimages. He had travelled through the whole country as a Mohammedan beggar —a Sunnite amongst the Sheites. The Sunnites amongst the Turks were accounted a lazy lot, and he had to suffer on their behalf, in fact, he had to endure more hardships in Persia than in Central Asia. These two routes of pilgrimage involved the main trade of the country. From the south there was a large quantity of travellers to Ispahan and Teheran, and on to Meshed, where they stayed

about a fortnight, and they very rarely returned home without taking something with them. The numbers who went there were twice as many as those who went to Kerbela, which lay almost on the border of Turkey. If by means of the Karún river, English goods could be taken far enough north their superior quality would beat the Russian goods; but the Russians were very shrewd, and were not so credulous as the English. They had conquered the whole of the north of Persia for trade, and when he was there he found the whole of that part crowded with Russian goods, which actually came as far as Shiraz. Russia had a concession to Resht, and would probably get a railway to Teheran, and another along the northern frontier. Under these circumstances he feared the opening of the Karún would not be very useful to England unless a railway were made from Shushter to Ispahan, or Kum. But the Shah did not give concessions to any nation without the consent of the Czar, and he did not believe he would ever consent. Englishmen seemed lately not to have been awake to their own interests, and to have lost their old spirit, and if this were not altered they would be entirely superseded by the Russians.

Mr. UNDERDOWN Q.C., said he could not claim to have been in Persia, but matters which had recently come to his knowledge rendered it extremely important to know what was likely to be done there. There was no doubt that the opening of river communication to the point indicated was a thing to be grateful for; but assuming Shushter were taken as the starting point, he would ask whether there was any probability of further communication being made by railway into the interior of the country. Mountains were no obstacle to railways now, for he, together with the Chairman, was interested in a line which reached a height of 13,000 or 14,000 feet, but that was in a country where the people had established what was more important even than rivers or waterways, viz., confidence in the safety of invested capital. Wherever capital flowed, railways would penetrate. The old pilgrim routes referred to by Professor Vambery would soon be superseded if a convenient and rapid means of communication were established. The making of railways was now merely a question of so much a mile, and if English capitalists could be assured that a reasonable interest would be returned on so much a mile they would soon find the money, provided public tranquillity could be secured; but that would soon follow the presence of a railway. He understood there was a range of mountains between Shushter and Ispahan, and another range not so high between the latter place and Teheran; but these physical difficulties were not of much importance if the capital were forthcoming. Reference had been made to a concession offering certain advantages to England, but, as a *contre coup*, the White Czar had obtained certain privileges with regard to the making of railways in the north; and he should regard it as very unfortunate if the advantages we gained by means of water communication were neutralised by Russia having exclusive privileges with regard to railways; but if we were not debarred doing so, he saw no reason why we should not also embark in railway enterprise, which would be the true key to the future of Persia. To aid in this, the Indian Government, the British Government, and the wealth of the English people might all be invoked, and such aid would no doubt be secured if they could see that their interests were involved, and that there was security for their money. No time should be lost in developing some system which should secure to us, first, the development of financial operations; secondly, trade advantages; and, lastly, some convenient trade route from the point indicated to Ispahan.

Mr. GEORGE MACKENZIE said there was one point of considerable importance in connection with the entrance to the Karún from Shat-el-Arab, and that was the depth of water, which was stated in the paper to be nineteen feet; but that was the depth at the bar at Fao, which might be easily removed, and beyond it there was depth enough for the largest vessels. He knew several persons who would undertake the removal of this bar if they were allowed; but the Turks, like the Persians, would do nothing whatever to facilitate commerce. He did not see why the Turks should have it all their own way, and perhaps the Persians, who were equally interested in the river at Fao, might be induced to allow this obstacle to be removed. As to the trade which might be likely to grow up, he could not say so much as Mr. Lynch, who was the father of trade in the Persian Gulf. When he first went there nearly twenty years ago he found Mr. Lynch's vessels were the only ones trading to these ports from England direct. He believed Mr. Lynch's first vessel brought home about 300 tons of dates, but he found that, in 1887, 20,000 tons of dates were exported from Bussorah to Europe alone. The trade in grain had also increased very materially, and this was very largely a grain-growing district. There had been famines in southern Persia when there was plenty in Kermanshah and Hammadan, though there was no possibility of relieving the famine in other places for want of communication. If this trade were opened up, even Bombay could be supplied in times of scarcity from the Persian Gulf. When Colonel Napier visited Kermanshah he found there some thousands of tons of surplus grain, having a nominal value of 10s. a ton. If the Karún were opened up, no doubt the trade in grain would increase to a much greater extent than that in dates. If the Shah would grant a concession, no doubt English capital would be forthcoming if there were a moderate guarantee; but to make it more secure the English Government should join in it, and he did not think there would be much risk, as there was no doubt that in a few years the line would pay itself. At the same time he did not advocate a line of railway being made immediately; the first thing needed was a road; nor

should he suggest the immediate making of a lock at Ahwaz, because it would merely feed the trade at Shushter. He should begin with a road from Ahwaz and carry it up by Shushter, and from there to Burijird direct. He would call attention to a very interesting paper in *Blackwood* of April last, by Colonel Bell, who described this road in three sections, first from Mohammerah to Dizful, 173 miles over a flat alluvial soil; the second section from Dizful to Khoramabad, 157 miles; and the third from thence to Koom, 142 miles. Of the whole distance he said there were 355 miles good, 100 fair, and only 80 miles bad; only one river had to be bridged. Looking at the map, and seeing how the Russians were tapping the country in the north, he quite agreed with Professor Vambery that there would not be much advantage to this country in opening the River Karún to navigation unless a road were made to Koom. He did not know who was to blame for the delay; twenty years ago he first took up the matter, and he had found both the India Office and the Foreign Office ready to give every assistance, but nothing could be done until the Shah gave his permission, which had now been granted. Immediately the river was thrown open it was occupied by Mr. Lynch's line of steamers, and they were quite ready to go on and make a road if they could get the necessary assistance from the Shah or the English Government. Colonel Bell said a cart road, 12 to 15 feet wide, on the hills, and 30 feet on the level, should not cost more than 200 rupees a mile. The sum seemed very small, but Colonel Bell was an engineer officer; and that would make the total cost of a road from Ahwaz to Koom only £10,000. There would be a good return on the outlay if the Persian Government would guarantee there should be no interference with the enterprise. He should not recommend a toll on the road, because the muleteers would go round, but should suggest a special tax on the grain carried. Sir R. Murdoch Smith had laid great stress on the importance of maintaining friendly relations with the natives, but if there was any difficulty on this point it would, according to his experience, be the fault of the Englishmen. He travelled across from Ispahan to Shuster as a perfect stranger, and was warned by the Ambassador at Teheran that he might be in danger, but travelling only with his own servants and horses, he always met with the greatest kindness and courtesy. The Persians were a hospitable, enlightened, and highly civilised people. When returning home lately from Africa he intended making a detour through Persia, and wrote to some of the chiefs whom he had visited before, but he was obliged to come home direct from Aden, and by the last mail he had received letters from some of these men expressing their regret at not seeing him again. He did not see why others should not be treated as well, for he only went as a simple traveller, and spent little or no money in the country. There were large petroleum springs on the Karún, which now ran to waste into the river; the petroleum was very pure, for he had seen it burnt in the bazaars at Ispahan, and he did not see why a similar trade should not be done on the Karún in this oil to that done by the Russians at Baku. The present cost of transport for ordinary goods by mule from Bushire to Ispahan was at least £15 a ton, which showed what an opening there was for improved means of communication.

General SCHINDLER said he had been several times up the Karún, and twice up the left bank. In 1886 he entered the canal which joined the Karún and the Shat-el-Arab to the Persepolis, then drawing 16 feet. At the junction at Hafa he noticed a sand-bank running out 40 yards, but this could easily be removed, and vessels of large draft could then always go into Hafa within 30 yards of the Mohammerah quay. The Shat-el-Arab formed the frontier between Persian and Turkish territory, but at a village called Fao the Turks had been building a fort, and persisted in so doing in spite of remonstrance. In the event of political differences, and the Shat-el-Arab being closed, the fact that there existed another river by which Mohammerah could be reached from the Gulf became very important. This river ran parallel to, and a few miles east of the Karún; it was about 200 feet wide, and its least depth about 6 feet, and it would make the Karún navigation altogether Persian, and independent of any other power. More important would be the reconstruction of the dyke, and making a dock or locks to raise the water of the river to the level of the banks, so that the surrounding land could be irrigated, for in this way a practically deserted district could be brought back to its former prosperity; for before the destruction of the dyke, probably in the 13th century, the province of Ahwaz was the richest in Khuzistan. He had not seen any mention of the destruction of that dyke in Persian histories, but it was ascribed in legends to a wicked merchant who "cornered" sugar, and after a time, when the price had gone up and he opened his bags, they were full, not of sugar but of scorpions, which were so venomous that when they dragged their tails over a thick felt carpet they cut it in two. These scorpions came out in such vast numbers that the people fled for their lives, and never returned. According to the latest British Consular reports, the annual imports and exports of Persia were 10,000,000, five and a-half of which came in and out by the Gulf, and 3,000,000 would go by the Karún River if the road from Shushter to the interior were opened. In spite of the facilities which Persia enjoyed in the north, English cotton goods still held their own, and in many places were sold cheaper, for it would take a long time before Russia could compete with Manchester. The present rates were 6d. or 7d. a ton per mile by mule, but with a cart road from Shushter to Teheran they could be reduced to 2½d. per ton, and still leave a large margin to those who made the road and established a regular service, without which the road would be useless. The

telegraph was now working half way from Kharremabad to Dizful, and it would be completed by the end of the year. He had been by that road about eight times, and had spent thirteen months in those mountains, where he was very glad to hear of the good impression which Mr. Mackenzie had left behind him. Only four months ago he received a letter from one of the chiefs, saying how he was looking forward to meeting him again.

Sir FREDERIC GOLDSMID said that this was one of the few parts of Persia which he had not personally visited, and as he had not seen the Karún river beyond the mouth, he was unable to add much to the discussion.

Mr. T. K. LYNCH said he had been connected with these countries from 1841, when, for the first time in the history of the world, his ships, rounding the Cape, opened direct communication between London and Bushire and Bussorah, and for many years his steamers alone kept up a line of direct communication with the Persian Gulf. When the Suez Canal opened, he entered into relations with the large commercial line in which Mr. Mackenzie was interested, and confined himself to river navigation on the Karún, Tigris, and Euphrates. On the two latter he had been very successful in developing trade, so that Manchester goods could now be delivered much cheaper in Teheran by that route than through Russia. The river freight was now from 28s. to 30s. to Baghdad, and about one per cent. more to Teheran; that being the main route for pilgrims to Kerbela and Nejif, or Meshed Ali, to the west of the Euphrates, the muleteers who brought down pilgrims were generally able to take back merchandise at a very cheap rate. The same thing applied to Hammadan. He had always argued for the Karún route as being essential for opening up the Shushter line, which was in the direct route from Mohammerah to Ispahan. He had been in the country for sixteen years, and had studied it intimately everywhere, except from Shushter to Ispahan, and that portion he knew from Sir Henry Layard's travels, and surveys by Captain Selby with Captain H. B. Lynch, and from what he learned from these gentlemen his eyes were opened to the great importance of the Karún. He had a launch, and navigated it nearly a year, but at Bussorah the Turks placed a heavy tax on every passenger, and he was obliged to give it up. The Shah having opened the river, his company had two vessels there within three weeks, which were now making fortnightly trips, though as yet at a great loss, having spent about £2,000 and only got back about £500. As Professor Vambery had very properly said, the Russians had the oyster and we had the shell, for there was nothing to be had by stopping our trade at Ahwaz. The Persians had given them half a loaf, which was better than no bread, but then they would not allow them to eat it. It was no use having access to the country unless they were allowed to deliver the goods at the emporium of trade. They had delivered goods at Hammadan and Teheran, giving through bills of lading from London, and employing muleteers; now it was said that could not be done, but that the Government must carry on the goods from Ahwaz. If that difficulty could not be got over, the trade would be too heavily handicapped to be successful, but he hoped the Government would insist on these restrictions being removed. If goods could be consigned and delivered to merchants at Shushter or Dizful an enormous step would be gained. The route from Dizful was a simple one, and the Persians themselves had sufficient enterprise to develop that without the assistance of England. If the Russians, however, insisted on getting a concession for a railway from the north to Teheran we ought not to be idle, and there could be no doubt that between Ispahan and Shushter the route for a railway was the easiest possible. In Europe railways were taken along the line of rivers, as in the Alps, and the same might be done here; and there was only one range of mountains between the plateau of the Zenderud, which watered the plain and city of Ispahan, and the sources of the Karún. And at one time it was contemplated to tunnel it and make a canal to divert the waters of the Karún into the plain of Ispahan, and, in the present day, nothing would be easier than to do so. That would open the whole of that part of Persia to the trade of England and India, which would be of great importance not only from a commercial but from a political point of view.

Mr. W. MARTIN WOOD remarked that there had been a decline in the relative influence of England and English interests in the north of Persia during the last twenty or thirty years. Twenty years ago there was a movement for opening up the navigation of the Karún, when it was opposed by the French, who had then more influence at Teheran than they seemed to possess lately; but, in any case, the question arises why was not this promising concession obtained long ago? He believed that the decline of English influence in Persia dated from the period when the British Embassy at Teheran, which had previously been under the Indian Government, and Indian officers who knew the Persians, was transferred to the Foreign Office, and placed in the hands mainly of men who were strangers to the East. If that were the case, the question arose whether it would not be wise to revert to the former state of things, and, more so, because it must be remembered that India, and not the British Treasury, pays the cost of the mission to Persia. The historical and literary aspects of the question were very ably treated in the paper in the Bombay branch of the Royal Asiatic Society which had been referred to. That paper by Mr. Jamsetjee J. Mody was ready in January, and could now be seen in the Society's *Journal* at the rooms in Albemarle-street.

The CHAIRMAN said the diplomatic question which had been raised by the last speaker hardly came within the scope of the discussion. He was aware that some gentlemen entertained strong views upon it, but, after all, Persia was intimately connected with European politics, and if the Imperial Government decided that it should remain with the Foreign Office, as it had since 1806, it was no use asking that it should be placed in communication with the Indian Government. He had to move a vote of thanks to Sir R. Murdoch Smith, whose paper had elicited as interesting a discussion as any he had ever heard. The country was much indebted to public-spirited Englishmen like Mr. Lynch and Mr. George Mackenzie, who carried the national flag into foreign countries, and he hoped that the paper and the interesting speeches which had followed would not be idle words, ending in nothing. All Governments, Liberal and Conservative alike, were weak and cowardly, and unless compelled to take action by public opinion and the trading interests, would do nothing. The Shah was about to visit England, and he thought some of the gentlemen present, with others of influence in the City, might form an association which should invite the Government, by arguments it could understand, to press on his Highness the desirability of granting England such further concessions in Southern Persia as might be necessary, including a railway line between Shushter and Ispahan. There was no time to be lost, only there should be due deliberation as to the exact course to be taken. He refused to believe that the commercial spirit of England had declined; and even the Government, in reply to hostile criticism, might justly say that they were annexing new regions, and acquiring new possessions every year; and he did not think the nation was quite so effete as some of their friends supposed.

Mr. HYDE-CLARKE seconded the vote of thanks, which was carried unanimously.

TWENTIETH ORDINARY MEETING.

Wednesday, May 8th, 1889; GEORGE BULLEN, LL.D., Keeper of the Printed Books, &c., in the British Museum, in the chair.

The following candidates were proposed for election as members of the Society:—

Burmester, J. W. Stanley, 36, Great James-street, Bedford-row, W.C.
Chapman, Albert Barnes, 2, Delrow-terrace, Buxton, Derbyshire.
Gardner, Samuel, B.A., Spring-hill, Upper Clapton, E.
Griffin, Samuel, Kingston Ironworks, Bath.
Higgs, William, Gas Works, Basingstoke.
Kenyon, Lord, Gredington, Whitchurch, Salop.
Smythies, Frederic Kynnersley, 52, Ravensdale-road, Stamford-hill, N.
Spencer, Richard, Holker-street, Barrow-in-Furness.
Tredegar, Lord, Tredegar-park, Newport, Mon.
Viney, Rev. Josiah, Alleyne-house, Caterham-valley, Surrey.

The following candidates were balloted for and duly elected members of the Society:—

Corbett, Thomas, 70, Camden-road, N.W.
Dunn, William Haynes, 9, Brownswood-park, Green-lanes, N.
Naylor, Robert Anderton, Cuerden-hall, Thelwall, Warrington.
Ram, Raizada Bhagat, Jallundhur, Panjab, India, and 14, Harley-gardens, W.
Saraswatee, Swamee Bhaskara Nand, Jodhpore, India, and 319, Fulham-road, S.W.

The paper read was—

THE ORIGIN AND MANUFACTURE OF PLAYING CARDS.

By GEORGE CLULOW, F.R.G.S.

The title of the lecture which has been announced for this evening is "The Origin and Manufacture of Playing Cards." It is well that the subject has been limited to these two divisions, because, to do them justice, either would require far more time than it is usual to give on such occasions as the present; while to attempt to treat playing cards under all their aspects would in effect be a history of the art of engraving, of the mechanical art of printing, and of the social manners of the people of Europe for the past 500 years.

Playing cards are now spread all over the world, and form the amusement of not only the cultured but of the so-called barbarous people of almost all countries, from the Apache Indians—who, at this day, use strips of sheepskin on which they paint rude imitations of the Spanish playing cards of 200 years ago—to the wily Hindoo with his circular cards, and their series of representations of the avatars of Vishnu, and suit signs in which with those of the western "tarot" there is still to be traced a common origin. Where are cards *not* played? Wherever the European has penetrated there cards have followed—often may be in the knapsack of the soldier, cards following conquest; but in spite of their universal adoption as a means of recreation they are probably more obscure in their origin than any other of the games of which we have any written knowledge, and they are a most curious and attrac-

tive subject to the archæologist and to the student of human nature.

It is necessary just for a moment to mention the use of cards for other than a purely recreative purpose, and which brings them within a broader range of interest. The disposition to seek decision upon matters which cannot come within the exact knowledge of the individual, by means which imply reliance upon the doctrine of chances, would seem to be almost an intuitive desire with mankind, and it is from this desire that the spirit arises which we call "gambling;" this is a peculiar attribute of the human animal, and we may, without risk of being considered over speculative, assume that playing-cards, whatever may have been the material of which they were made, were from the first made for divinatory purposes and for "gambling"—divination being but a gambling with the possibilities of the future, and thus when so used, taking the place of the oracle of the Greeks, and the augur of Ancient Rome.

The origin of cards has been speculatively placed at a period—which so far as accurate knowledge of the subject goes, can hardly be termed historic, but I propose only to take dates which may be reliably traced and proved by existing authorities.

It is popularly considered that playing cards had their origin in the year 1392, and that they were invented as a means of amusing Charles VI. of France; but there can be no question that the cards upon which such erroneous conclusion has been formed, and some seventeen of which still exist in the National Library in Paris, were but repetitions of models which had been in use long before; these cards, from the painstaking elaboration which has been expended upon them, being evidently specially prepared as *cartes de luxe* for the king, who would certainly have been familiar with their use in the ordinary form. These cards are fine specimens of delicate painting, and they have about them a mysterious grotesqueness which give them a strange attraction; and you have a *facsimile* of one of them now before you. We have in the German treatise, "Das Guldin Spil," printed in 1482, an assertion that the game of cards was introduced into Germany in the year 1300, but the manuscript authority being wanting, it may be that this date is open to question. An Italian chronicle gives the year 1379 as that when the game was introduced into Viterbo; and the records of the city of Nuremberg make mention of cards between the years 1380 to 1384. But Mr. Bond, late Principal Librarian of the British Museum, has called a witness as to date which is of interest, for in that collection he has found a Latin MS. entitled "De Moribus et disciplina Humane Conversationis," which contains a moralisation of the game of cards; its author, who describes himself as "Johannes in ordine prædicatorum minimus Theutonicus," asserting that cards were introduced in the country in which he was writing in the then year 1377. Translating him, he says:—"Hence it is that a certain game called the game of cards (*Ludus cartarum*) has come to us in this year 1377;" and he goes on to say, "but at what time it was invented, where, and by whom, I am ignorant. But this I say, that it is of advantage to noblemen and to others, especially if they practice it courteously and without money."

I should like to quote at length from this treatise did time permit, as it has a very capital description of a game of cards, but its interest has special reference to one of the points to which I propose to call attention in respect to cards, viz., the intense conservatism which has belonged to their pictorial aspect for 500 years. In the first chapter he treats "de materia ludi et de diversitate instrumentorum;" and he says that "in the game which men call the game of cards they paint the cards in different manners, and play with them in one way and another;" showing that they were well-known, and had been in use sufficiently long for more than one kind of game to be played with them, and further, "as the game came to us, there are four kings depicted on four cards, and each one holds a certain sign in his hand, and that under the king are two 'marichali,' the first of whom holds the sign upward in his hand, and the other holds the sign downward in his hand." These two marshals are represented in the cards of the 15th century, and onwards, by the queens, and knaves, or varlets, and it is very interesting to note that in the hands of the knaves of the playing cards of to-day the staves are in two of them held upwards, and in the other two downwards. He goes on to say that under these first-named three cards there are to each king ten other cards, on each of which the king's sign is placed, on the first once, on the second twice, and so on; and thus we have in the year 1377 conclusively not only a fixed date but also the fact that the pack consisted of 52 cards, disposed

in four groups of 13 each, He was clearly writing not of the tarot pack of 78 cards, of which I shall speak presently, but of the picquet pack of 52 cards as best known now to us; therefore it may be with certainty assumed that this year might be considerably ante-dated to arrive at a period indicative of the origin of the game of which he writes.

In the National Library in Paris there is a MS. translation of the Cité de Dieu of Saint Augustin, by Raoul de Presle, of the date 1375, which has a minature representing three personages sitting at a table and playing at cards, and in the "History of Jean de Saintre," who was a page of Charles the Fifth, we find the governor of the pages reproaching them for playing at cards; while in the "Pilgrimage of Man," a poem composed in 1350 by William de Guilleville, and printed by Verard in Paris in 1501, we find, "Jeux de tables et de cartes."

There are earlier dates referred to in various MSS., one of them so early as 1299, but they are more or less open to doubt, on the grounds of want of accuracy in copying; but taking the evidences before us, and allowing for questionable authority, we may take it as a fact that playing-cards were in common use in the early part of the 14th century, and that thus to assign a period of 500 years for their familiar use is quite within the mark.

"Tarot" cards are the earliest form of playing cards known to us, and we have to account for their introduction into Europe by means of the gypsies—supposedly some Pariah or low caste Hindoo race, swept by a northern irruption westward through Persia and Arabia, through Egypt, and along the Mediterranean into Spain, and so through Europe. Cards in connection with gypsies are matters of common recognition, and fortune-telling and gypsies are almost synonymous. In Southern Europe as in England cards are part of the stock-in-trade of this wandering and predatory race of curious people. Tarots are not known to us in England except as curiosities, awakening speculation by the strange series of 21 "atouts"—the major card, known as the "fou," and the four "cavaliers," which, together with the usual 52 cards, make up the tarot pack of 78. Tarots are still made in France, largely in Italy, and in lesser quantity in Germany, and they have preserved, with little variation, the same singular features as to the "atouts" which were seen in the tarot cards of 400 years ago. The comparison of a pack of a date about 1500 with one of Italian manufacture of the present day, shows among the four variations which occur among the "atouts"—a card bearing a similar figure to that now named "le pape," but then named "la papesse," a seeming survival of the fabulous story of the election, in the 9th century, of a female Pope. The cards known as the cards of Charles VI. belong to a tarot pack, and you have now on the screen a *fac-simile* of one of them.

"Tarot," or tarocchi, is still played in Southern Europe, and it is to this game that we owe the creation of the very artistic series of designs by Mitelli, which illustrates the tarocchi of Bologna, produced about the year 1664. I do not follow the ingenious but far-fetched fancies of Court de Gebelin, who, in 1781, wrote a very remarkable article on the subject of tarots, finding all through them an entirely Egyptian origin; but we have enough before us to enable us to adopt the tarot cards as the earliest form of playing cards, and to see in them a distinctly Eastern symbolism, which fits them to the hypothesis that it is to the gypsies that we may look as the carriers of the game westwards from the east. To discuss the features of Chinese playing cards, and to find in them some remarkable semblance to the tarot cards, would take us too far a-field, but such resemblances cannot but suggest a common origin, and when the intense conservatism of the Chinese be borne in mind, we may well conjecture for their cards a date far beyond anything within our historic period. In this immediate connection it is noticeable that in the playing cards of Southern India we find among the suit marks the sword, money, and bells, as in the modern tarot packs of Europe. It is easy to follow this idea on to the 15th century, and to link the past and the present by a reference to the names upon the earliest existing examples of cards bearing the suit signs best known to us in England, viz., spades, diamonds, hearts, and clubs, for on these early examples we find not the heroes of that period, but those of an earlier period, "Coursube," "Appollin," &c.

It being conceded that cards were of Eastern origin, it needs only for us to trace the natural course of travel westward for us to name the country which in Europe may claim their first adoption; and as this course would certainly be along the northern African coast to Tangier, it is in Spain that we may reasonably look for their first foothold; and this idea is strengthened by the fact that all the earliest games of cards are of Spanish invention, and that the Spaniards have to this day retained the dis-

tinctive suit signs of cups, money, swords, and batons, as in the older tarot cards.

I refer again to the Italian chronicle, which gives the year 1379 as that of their introduction into Viterbo, only to note that it speaks of them as coming from the Saracens, who called them "Naib," and we have a survival of this word in the name "Naipes," by which designation playing cards are known in Spain at this day.

We have, however, to deal now more with the period when playing cards, in the form in which they are familiar to us, were first known in the country from whence they reached us. We may with certainty place this date as the middle of the 15th century, and the wars of that country with Spain may well have enabled the knowledge of them to pass from the one country to the other.

In the absence of actual proof of the date of introduction of the suit signs known as the French, or "Piquet," and to us as hearts, spades, diamonds, and clubs, we have to bridge over a considerable interval to reach the middle of the 15th century, when we have numerous existing examples of cards bearing those signs, two of the earliest of them are here shown; and it is to this period that so much interest attaches as that co-incident with the invention of the art of wood engraving. With this invention, and the means which it gave for easy and rapid multiplication, we may well look for an expansive growth and use of playing cards. It has been said that the wood-engravers produced blocks for cards before they produced those for Bibles, and we may well believe this to have been the case, for the recreations of the people have always had a more easily accessible place than their religion. The 15th century is that of the invention of engraving on wood and on metal, by either of which method design could be multiplied indefinitely; and when printing, full grown and equipped, sprang into existence, it found waiting for it the art of the engraver to aid, by graphic delineation, the wondrous spread of knowledge of which it was to prove the creator.

Going onward, to find a period for the introduction of cards into England which should be somewhat approximate to the date of the invention of wood engraving and of printing, we reach the reign of our King Henry VI.; and the constant wars between this country and France under Charles VII., and the crowning of Henry VI. at Paris as king of France, furnishes us with an easy conjecture as to the time and circumstance under which French cards would find their way into England, and serve as the models thereafter for the cards manufactured there. We now, however, reach the region of fact, and have documentary proof in support of dates, for in a list of articles, the exportation of which was prohibited, mentioned in an Act of the 3 Edward IV., 1463, passed for the protection of the tradesmen of London, we find "cards for playing;" proving their familiar use before that period. From this time onward we find frequent mention of them in legal enactments, made in protection of the home manufacture, and for the regulation of the pastimes of the people; and it is, among other items, amusing to find that when James IV. of Scotland came a-wooing Margaret, the daughter of Henry VII., he found her playing at cards!

It could not have been long after the invention of wood engraving that the idea of colour, in imitation of the art of the painter, came to supplement it, and we find in the earliest block books that colour is applied to the printed outline by means of a brush, either direct or by stencil. In Nuremberg, early in the 15th century, *forme schneiders* (or block cutters), and *karten mahlers* (or card painters), were working together, and the painter under this description was the workman who, by means of brush and stencil plate, coloured outlines, whether of Bibles or playing cards, which had been produced from wood blocks.

Italy and Germany were not far apart in point of date in the production of printed playing cards, and we find in both countries, in the middle of the 15th century, various protective laws in favour of the workmen who were engaged in their manufacture in these two countries. I pass over the period from 1450 to the end of the 18th century, or a period of 250 years, during which there would not appear to have been any material changes in the method of manufacture of cards, while the materials employed remained the same.

Up to within the last twenty years it was the universal belief in England among the makers of playing cards that a good card could not consist of less than four sheets of paper, following in this the traditional trade rule of the French makers, from whom our manufacture has come. But the changes incident upon fashion and example from other countries have altered this, and we have, to-

day, cards made of three, two, and sometimes of a single sheet. These four sheets consisted, first, of two sheets of a strong specially made cartridge paper of a low brownish colour, and two sheets of a hard-sized white paper, which was made either wove or laid according to the fancy of the card maker, the "laid" being the most used. From the examples preserved in various collections which have remained in the sheet without being cut up into single cards, and which date from the early part of the 16th century, it would appear that a sheet that would serve for the manufacture of twenty cards was that most approved by the card makers, and the size of this sheet, which was technically described as "pot," has varied at different times from 10½ in. by 14 in. to 14 in. by 17 in., being approximately the size now known as foolscap.

When the stencil had given place to colour-printing by the hand or steam press, the sheet which was destined to form the face of the card was printed by letter-press from wood, stereotype, or electro blocks successively in the various colours used, the Court cards (catachrestic for coat or heraldic) being printed with a blue outline, which was followed by the yellow, flesh, black, and red printings, and the "pips" or "points" on sheets each of their own colour, red or black. An essential of this process of printing in which oil colours are of necessity used—as will be seen when the operation of pasting is borne in mind—is that great care should be taken that the inks employed should be prepared in such a manner that the minimum of time may be required in the drying before the operation of pasting is reached. This drying process is attained by the sheets when printed being hung over rods or cords, in batches of 10 to 30 sheets, in heated chambers or chambers to which there is free access of air, for a period varying—according to season and to the facilities of the manufactory—for from three to twelve months.

The card being formed of four sheets, the two inner sheets, or "literis," is made by the pasting together of two sheets of the strong cartridge before mentioned, which are dried and kept in stock as other paper. The next process is to "mingle" the two outer sheets preparatory to their being pasted into the card, and this is done by the placing alternately of a printed sheet, forming the face, and a plain sheet which is to form the back; this being done, one pile is formed of those sheets, and another of the previously pasted double sheets or "literis." With these before him, the paster takes a sheet of the white paper and lays it on the pasting table, proceeding with a broad, flat brush, to paste it all over with a strong flour paste, in which sometimes a small proportion of glue or gelatine has been mixed. He then places on this a sheet of the "literis," and, in turn, pastes the upper side of it in the same manner; he next takes two of the mingled sheets together which are alternately printed and plain, and places them on the pasted "literis;" there is then pasted a complete board with the white sheet ready in position for the next pasting, and the work so proceeds till the pile is finished. The next process is to lift the pile to the press, which is either what is known as the "standing press"—the oldest method of getting pressure by means of a screw bringing down a block upon the bed of the press—or by the modern hydraulic press, the object being to squeeze out all the superfluous paste from between the sheets, and which, exuding at the edges, runs away at the foot of the press. The lessening bulk of the pile under this operation is provided for by the screw or hydraulic ram as the case may be. This ordinarily takes 12 to 20 hours, and the sheets are then ready to be removed to the drying-room, where they are hung on cords, having been previously pinned or wired together in pairs, the pinning forming in effect a hinge which carries the sheets over the cord, or they are hung in a similar manner in pairs by means of clips of combined wood and metal, or the common wooden peg, known as the American clothes peg—the clips or pegs being screwed to rails fixed at proper intervals. Pegging or clipping is the preferable method, as by it the risk of damage by careless wiring or pinning is avoided. The length of time during which the boards require to be so hung depends entirely upon the temperature of the rooms and the perfection of the ventilation. The object of this operation being to get rid of all moisture from the card, it is evident that the more perfect the means for getting rid of the evaporated moisture the more rapidly the boards come forward for the next step towards the finished card, but from four to eight days is usual. The boards are now in the state known as "rough," and are ready for either enamelling or for being finished without enamel. The demand for a perfectly plain card, that is one without any enamel, still exists to a small extent, but the trade is now almost entirely

in cards which have on their backs a coating of colour known as enamel, either left plain or by a subsequent operation printed with a device or pattern in one or more colours. If to be finished plain, the boards pass next to the "soaping," which is an operation consisting of putting on the surface of the board a thin dusting of powdered talc, which is known commercially as French chalk, this being done either by hand or by a machine; this gives to it an easier "slip" and assists materially that finish which the board ultimately acquires in the next process of rolling. If to be enamelled, the boards go from the "rough" to the hands of the colourer, who puts, by a brush, on the plain side of the board a coating of so-called enamel, which is colour with a base of different proportions of baryta, china clay, and oxide of zinc, made up with a vehicle of gelatine size; each board as it is coloured being placed upon a rack till sufficiently dry to be stacked away ready for the next process, which may be simply "glazing," in the case of cards with plain enamel backs, or when to be decorated on their backs with one or more printings, to the "flatting" which is a modified "rolling," the object being to get a flat and even surface for the printer. As it is of the greatest importance that the fronts and backs of the cards should be in absolute "register," it is usual to pierce in the margins of the sheets which are to be subsequently printed at their backs two or more perforations, which serve as the points for either hand-press or machine, and this is done before they are sent to the workman who prints the back. The backs are printed in the same manner and by the same methods as are the faces, a separate "forme" being used for each colour employed.

After the boards have left the printers of the backs, they are again taken to the drying-rooms, where for a time—varying from a few days to months, according to the requirements of the trade—they are left in stacks to mature and to harden, the completion of this process being accomplished in drying-cupboards, where by means of steam-pipes, or air otherwise heated, they are kept in a temperature of from 96° to 110° Fahr. for a few days. This "sets" the colour used in the printing, and gives to the card the "snap" and elasticity which is one of the essentials of a good card. This being completed, the process of soaping, as before described, comes next, and they are then ready for "glazing." Glazing, or polishing the card, is now done by means of polished copper or zinc plates, the boards being placed between them, and the whole passed between two cylinders of polished steel. The glazing is got by combined pressure and friction, the slight movement of the plates, one upon the other, as they pass through the cylinders giving friction together with pressure which polishes the surface alike of the plain and the enamelled sides of the board, and the extent of this polish depends upon the number of times the plates containing the boards are passed between the cylinders. The boards are now ready for cutting; and here, as in other details of card-making, machines have largely superseded hand labour, but I will briefly describe the two methods of cutting up the sheets, taking the oldest method first—that by hand. The instrument employed is known as a "shears," which is simply a long blade, not unlike one blade of a pair of scissors, fixed as to its point by a bolt to the upper edge of the cutting-table, the other end being shaped into a handle (exactly as is shown in the slide now on the screen). The sheet being pressed under this blade, it is cut successively into "traverses." Thus in a sheet of 20 cards there would be a group of four traverses, each consisting of five cards. This is known technically as cutting "at long." These traverses are in turn taken to a smaller shears, and are there in a similar manner cut into single cards, or cut "at short." We have now a pile or "work" of cards as they come from the shears, ready for making up into packs. The pile is then ready for "laying." This is done by women, who proceed to lay into fifty-two separate piles the "work," each pile consisting of cards of the same denomination, thus the ace of spades is a pile by itself, and so on; this operation, as a rule, is preceded by a previous sorting of the cards, with the object of throwing out any of them which may have been soiled, or damaged, or are "out of register." The "laying" being completed, the worker then proceeds to take one card from each pile till the whole fifty-two cards forming the pack are gathered, and they then are placed crosswise, pack upon pack, as they are gathered, ready for the final operation of "wrapping" in the cover, or, as it used to be called, the "binder," in which they ultimately reach the purchaser. We have now a finished pack of cards, ready for sale either for export or for home use; in the latter case, before it can leave the premises of the manufacturers, it has to bear the "duty label," that is the stamp issued by

the Inland Revenue Department, as the means of collecting the duty of 3d. per pack levied on all playing cards sold for use in the United Kingdom. This tax upon playing cards is universal in Europe, with the exception of Spain, America being the only other country which does not now tax playing cards sold for home consumption. France collects this tax by means of the paper used for making the cards, which is manufactured specially, and is sold by the Government at a rate which covers the tax. The method used in this country is cumbrous, and may with advantage to the revenue on the one hand, and the convenience of the manufacturer on the other, be re-considered in comparison with the method for collecting the tax which was in use in the United States up to 1882, which was by means of an adhesive stamp of about the same size as our postage stamp, which was placed on the pack, not before it left the manufacturer, but as it left the retailer; or with that now in use in Italy and Germany, each of which countries impress a small device upon the ace of hearts, indicating that the tax has been paid, as now shown on the screen.

You will expect me to say something as to the relative merits of the playing cards made in different countries, and I am able to do so from a very complete collection of the cards made in every country in Europe—in Russia and in America. I speak now without reference to the playing cards of the East—India, China, and Japan—which are distinctively apart from all other playing cards both as to their material and their manufacture. I find it difficult to do this with perfect frankness without running the risk of offending the prejudices of some who may be present; but as the object of this paper is to convey information I am compelled to say that the playing cards made in England are inferior in material and in manufacture to those made in two other countries. I place America first, and next Russia, then England, Sweden, Germany, Spain, Italy, and Belgium. Part of this may be due to protection in some of these countries, notably America, which has an *ad valorem* tariff against imported cards of 100 per cent., thus enabling the manufacturer to rely upon higher prices being obtained for his wares than the English manufacturer can do, exposed as he is to the competition of the world, upon a nominal tariff only; but as to workmanship, very much, I fear, is to be found in the fact that the English workman has not yet learned the lesson which he *must* learn if he is to hold his own with others, viz., that the day has gone by when the name of "English," as applied to manufactures, was sufficiently indicative of good quality and approximate perfection, because perfection, as applied to manufacture, is only a relative term, and English manufacturers in this, as in other trades, are being daily outstripped in the race for trade by nations whose workpeople are trained not to be satisfied with anything which is not the best that human hands can produce, and the foreign workman is well learning the lesson. I am, in saying this, however, glad to be able to reserve a point in favour of the English manufacturer, for in no other country has the decorative treatment of the backs of playing cards had the development which it has received here. Germany has for some years followed us in the decorative treatment of the backs of cards in more than one colour, but these are for the most part indifferent in design, while they are fairly good in execution. In Russia there is also an advance in this direction, the designs being simply geometric and harmless, while they are well and carefully printed; here also, as in America, the question of price obtained, it is right to say, enters largely, for in Russia the price is high, and, moreover, the manufacture is a monopoly of a member of the Imperial family. In Germany there have been issued at intervals playing cards for special purposes which present features of luxurious treatment which cause them to stand alone, and I have been unable to resist the temptation of showing you two slides giving a reproduction, in one case, of the face, and in the other of the back, of a card from a pack which were produced for presentation to the late Emperor Frederick, upon the occasion of his silver wedding. I regret that I cannot show you the exquisite printing of the faces of these cards; they are simply perfect, but in their production the lithographic and not the letterpress process has been employed.

The decoration of the backs has been a special feature of the playing cards manufactured in England within the last 40 years, and it had its first really artistic development in the hands of the Messrs. De la Rue, who nearly 30 years ago, under the able art control of Mr. Owen Jones, produced in great variety playing cards with floral, heraldic, geometrical, and other devices printed in colours varying from one to seven. One of the earliest of these, and one which was very popular, and I believe is so still, was the "cotton plant,"

which you see upon the screen, and which will be recognised by some of those present as a marked development in the art of colour-printing as applied to playing cards. From this period forward, and in the hands of various manufacturers, notably in those of Messrs. Goodall and Son, there has been produced a constant succession of decorative designs, of more or less artistic merit, and for which the rapidly-growing taste for graphic colour has ensured a continuous demand. Among the most successful of the designers for this special manufacture have been Owen Jones, Robert Dudley, John Leighton, the brothers Audsley, Noel Humphrys, W. S. Coleman, and Lewis Day, the latter especially standing in the front rank of the decorative artists of to-day; and I will show you a few examples from the designs of these artists, which serve to exhibit the various fancies of the designer, and all of which have proved acceptable to card players.

It may have occurred to some of those present to inquire as to the origin of the titles which we find attached to playing cards, and some ingenious but erroneous speculation has been given to explain what is, in fact, capable of very easy solution—to do this, I must for a moment take you across the German ocean to the Low Countries, where so early as the year 1427 the card-makers of Tournai had formed themselves into a corporate body or guild, and among other protective ordinances framed by the guild, there was one giving the right for every member to enter upon its records any distinctive mark which he wished to put on the wrapper or binder of the cards made by him, which mark thereby became his exclusive property, an early instance in fact of the use of trade marks. It was not till the year 1629 that the playing card makers of London formed themselves into a similar body under the title of the Company of Makers of Playing Cards, and obtained the protection of a Royal Charter; having done so, they appear to have framed rules for their self-government very much upon the lines of the card-makers of the Low Countries.

Among these rules was one providing for the entry of the minutes of the Company of any marks which a member of it might desire to protect. The archives of the Company records the entry of a very large number of such marks, very few of which have survived; and it is worth noting that two of these marks, the Rose and the Wild Boar, were identical with the marks registered 200 years earlier by the Tournai card makers. I do not take into account the variety of titles which have within the past few years sprung into use, and will refer only to those which survive after an existence of more than a century and a half, and to now place upon record the dates of their first use; thus in 1706 there was entered the mark of King Henry the VIII., in 1714 the mark of the Merry Andrew, and in 1741 the Great Mogul and the Valiant Highlander were both of them entered by Christopher Blanchard; and it may be worth while to mention that a process of gradual evolution has in our own day placed these marks as indicating quality in the following order:—Great Mogul, Henry the VIII., Valiant Highlander, Merry Andrew. For the last 80 years all of these marks appear to have become the property of any card maker who choose to "annex" them.

We have now reached the 19th century, when the increasing knowledge of the mechanical arts gave a new development to all manufacturing processes, and brought in its train considerable changes in the methods of production of cards, especially in the substitution of printing in colour for the colouring by stencil. We have reached a time when the familiar knowledge of everyone present will enable them to grasp the great change which this has involved, which has resulted in giving us to-day, in place of the thick and often clumsy and rough, imperfectly cut, and always faultily-printed cards of a century ago, the beautifully printed satin-surface-like cards of to-day, with edges so faultless that, cut them where you may, and place them how you will, a perfectly even edge is presented, at once a pleasure to the eye and a safeguard against the malpractices of those who have no doubt often found their advantage in the imperfections of manufacture of the cards of a bye-gone time.

During the reading of the paper a large number of slides were shown illustrating various processes of card-making, and a series showing reproductions of old playing cards, indicating their use in education, and as aids to teaching history, geography, heraldry, astronomy, caligraphy, music, &c., as also the political use of playing cards in the 17th century, the reader of the paper giving a brief description of each as they were thrown upon the screen.

DISCUSSION.

The CHAIRMAN said it was many years since his attention was first drawn to this subject, when, soon

after he went to the British Museum, being much interested in the history of printing, he prepared some lectures upon it, and in so doing he had to treat on the history of playing cards. On investigating what was then known, he found it was considered doubtful whether cards were introduced from the East or owed their origin to a European invention, the current opinion, however, being that they came from China or some other country in the East. As the invention travelled into Europe it was made available by the clergy to introduce religious subjects, and in process of time inscriptions were added, and formed a most important part of the wood blocks from which the cards were printed, and ultimately books were printed consisting entirely of text, which were called block books, and from these it was supposed that printing took its origin, though whether it was due to Gutenberg or to some one in the Low Countries was even yet doubtful. Cards, therefore, were not merely interesting as objects of amusement, but in all probability they led to the invention of printing. Some people looked down upon card playing as frivolous, but to such he would recommend the saying of Talleyrand to a lady who expressed a similar distaste for them :—"Oh ! madame, what a dismal old age you are preparing for yourself." Whist occupied but a small share of attention in a book called "The Complete Gamester," by Charles Cotton, the first edition of which appeared in 1674, and from which it appeared that there were some 20 or 30 other games in vogue at that time. From the edition of 1709, it appeared that one point greatly insisted on by the author was the care required to avoid being cheated. He referred to the advantage of seeing your adversary's cards, and described various signals in use by which even an occasional glimpse might be made useful, and the knowledge required conveyed to the player's partner. He said, "Some have a way of slicking with a slick stone all the honours very smooth, by which means he may be sure to cut his partner an honour, and so his partner to him again," and added—"it is impossible to show you all the cheats of this game." In another book, under the same title, by Richard Seymour, published in 1750, and written "for the use of the young princesses," similar warnings were conveyed, and a description given of "piping" in these words :—"By piping I mean when one of the company that does not play sits down in a convenient place to smoke a pipe, and so look on, pretending to amuse himself that way. Now the disposing of his fingers on the pipe while smoking discovers the principal cards that are in the person's hand he overlooks, which was always esteemed a sufficient advantage to win a game." Then he described certain signals, and said "as soon as these methods become known, new ones are invented; and it seems certain that two persons will discover to each other what sort of cards they have in hand, and which ought to be first played, many different ways, without speaking a word."

Mr. C. HORSLEY, on being called upon, said that although he was Master of the Company of Playing Card Makers, he was not a maker of playing cards, and was not in a position to add anything to the very exhsustive paper they had heard from Mr. Clulow, who in due time would be his successor as Master of that Company.

Mr. JOHN LEIGHTON said :—There appears but little doubt that the rise of the playing card may be traced back to prehistoric time through dice, up to dominoes, the king and queen being added to the pips, and the pips being changed into clubs, diamonds, hearts, and spades. Chess probably grew out of cards, and both, as we use them, bear the impress of feudal times and of remote antiquity. I am sure that we all feel greatly obliged to Mr. Clulow for his very able paper upon a subject with which he is technically so well acquainted. The Clulow collection of books connected with cards contains many examples of great rarity and value. Mr. Clulow having mentioned my name in connection with two of the most popular card backs extant, I must say that much was due to time and subject—the Shakespeare card having grown out of the tercentenary of the poet's birth, and the Cleopatra double pack out of the Alexandrian needle, that was so nearly lost in its big bottle when that vessel was abandoned in a tempest in the Atlantic. Of complete sets, Mr. Clulow has made no mention of my Masonic set. Of cards we find faces reflecting all sorts of subjects, political, social, heraldic, and scientific, but it is a curious fact that "The Craft" should never have had its set, until it was carried out by me at the suggestion of Mr. John Hogg, the publisher, the picture cards having effigies of the Prince and Princess of Wales, and the Royal Brotherhood. At the instigation of Mr. Clulow I know that I once designed an improved set, to run against the popular, conventional, double-headed Tudor pack, so well known to us all, and with which our great-grandfathers used to gamble, and our great uncles utilised by cutting the card into four, making the white side serve as an address card. I well remember seeing respectable names and addresses adorning one side of a card, whilst the other displayed the fourth part of a picture card, or a red or black pip, as the case might be.

The CHAIRMAN then proposed a hearty vote of thanks to Mr. Clulow for his able and instructive paper, in which he had shown a vast amount of research, and information gained not only from books, but from his own observation in places he had visited, and from the collection of cards which he had himself formed. He must say that he had himself learned several things which he did not know before, and which were most interesting.

The vote of thanks having been carried unanimously

Mr. CLULOW, in responding, said he should be glad on some future occasion to give further information on points which time had not allowed him to go into that evening.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings at Eight o'clock:—

MAY 15.—"The Street Traffic of London." By J. STEPHEN JEANS.

MAY 22.—"The Use of Spirit as an Agent in Prime Movers." By A. F. YARROW.

MAY 29.—"The Science of Ventilation as applied to the Interior of Buildings." By D. G. HOEY. Sir DOUGLAS GALTON, K.C.B., F.R.S., will preside.

APPLIED ART SECTION.

Tuesday evenings, at Eight o'clock:—

MAY 14.—"Venetian Glass." By DR. SALVIATI. J. HUNGERFORD POLLEN will preside.

INDIAN SECTION.

Friday evenings, at Eight o'clock:—

MAY 31. — "Indian Wheats." By JOHN McDOUGALL. J. M. MACLEAN, M.P., will preside.

Attention is drawn to some alterations in the above dates. The reading of Mr. Lorraine's paper on "Automatic Selling Machines" has been postponed.

CANTOR LECTURES.

The following course of Cantor Lectures will be delivered on Monday evenings at Eight o'clock:—

H. GRAHAM HARRIS, M.Inst.C.E., "Heat Engines other than Steam." Four Lectures.

LECTURE II.—MAY 13TH.—Boyle's law—Gay Lussac's law—Expansion—Indicator diagrams—Watt indicator—Original instrument—Richards—Modes of testing engines—Balance-sheets—Division of classes—Hot-air engines—Types of these—Use of regenerator — Stirling — Bucket — Ericsson — Bailey —Rider—Other engines—Possible efficiency—Actual efficiency—Losses—Practical difficulties—Modes of overcoming these—Suggestions for improvement.

LECTURE III. — MAY 20TH. — Gas-engines—History—Lenoir—Hugon—Electrical firing—Direct flame firing—Otto and Langen—Bischoff—Compression—Crossley—Crossley's igniter—Clerk—Atkinson —Griffin—Other engines—Turning effort on crank shaft—Possible efficiency of the gas-engine—Actual efficiency—Losses—Practical difficulties—Modes of overcoming these—Suggestions for improvement—Crossley's compound gas-engine—Turning effort on crank shaft—Application of the regenerator—Siemens's regenerative gas-engine—Dowson gas—Water gas.

LECTURE IV.—MAY 27.—Petroleum-engines—Brayton and others—Other forms of heat-engines—Gunpowder pile-driver — Guncotton-engine—Honigman's caustic soda engine—Mixed air and steam-engine—Ether and steam—DuTrembley—Recent American experiments — Yarrow — "Arktos" — Electrical heat-engines — Thermopile — Edison — General conclusions.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, MAY 13...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. H. Graham Harris, "Heat Engines other than Steam." (Lecture II.)

Geographical, University of London, Burlington-gardens, W., 8½ p.m. Mr. J. R. Werner, "The Congo and the Ngala and Aruwhimi Tributaries." Discussion on the Letter of Mr. H. M. Stanley read on April 8th.

TUESDAY, MAY 14... SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Applied Art Section) Dr. Salviati, "Venetian Glass."

Royal Institution, Albemarle-street, W., 3 p.m. Dr. J. P. Richter, "The Italian Renaissance Painters: their Employment." (Lecture III.)

Medical and Chirurgical, 53, Berners-street, Oxford-street, W., 8½ p.m.

Civil Engineers, 25, Great George-street, S.W., 8 p.m. Discussion on Mr. W. H. Greenwood's paper, "The Treatment of Steel by Hydraulic Pressure, and the Plant employed for the purpose."

Anthropological, 3, Hanover-square, W., 8½ p.m. 1. Mr. Arthur Thomson, "The Osteology of the Veddahs of Ceylon." 2. Mrs. R. Braithwaite Batty, "Notes on the Yoruba Country." 3. Mr. H. Ling Roth, "Salutations."

Colonial Institute, Whitehall-rooms, Hôtel Métropole, S.W., 8 p.m. Mr. E. N. C. Braddon, "Tasmania; its Resources and Prospects."

WEDNESDAY, MAY 15...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. J. S. Jeans, "The Street Traffic of London."

Meteorological, 25, Great George-street, S.W., 7 p.m. 1. Mr. W. H. Dines, "Account of some Experiments made to investigate the connection between the Pressure and Velocity of the Wind." 2. Mr. C. H. Blackley, "On an improved Method of preparing Ozone Paper, and other forms of the Test, with Starch and Potassium Iodide." 3. Mr. Frank Russell, "On the Climate of Akassa, Niger Territory."

Pharmaceutical, 17, Bloomsbury-square, W.C., 11 a.m. Annual Meeting.

Botanic, Inner Circle, Regent's-park, N.W., 2 p.m. Summer Exhibition.

Archæological Association, 32, Sackville-street, W., 8 p.m.

THURSDAY, MAY 16...Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

Sanitary Institute, Parkes Museum, 74A, Margaret-street, W., 5 p.m. Mr. H. E. Davis, "Fires and Fire Escapes, and the Prevention and Arrest of Fires."

Chemical, Burlington-house, W., 8 p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Prof. Dewar, "Chemical Affinity." (Lecture I.)

Telegraph Engineers and Electricians, 25, Great George-street, S.W., 8 p.m.

Historical, 11, Chandos-street, W., 8½ p.m.

Numismatic, 22, Albemarle-street, W.C., 7 p.m.

FRIDAY, MAY 17... United Service Inst., Whitehall-yard, 3 p.m. Capt. G. H. V. Noel, "The Training of the Executive Branch of the Navy."

Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting, 9 p.m. Prof. Silvanus Thompson, "Optical Torque."

Philological, University College, W.C., 8 p.m. Rev. Dr. Richard Morris, "Pâli Miscellanies."

SATURDAY, MAY 18...Royal Institution, Albemarle-street, W., 3 p.m. Mr. J. Bennett "The Origin and Development of Opera in England.' (Lecture III.)

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FRIDAY, MAY 17, 1889.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

MOTOR TRIALS.

The report of the Society of Arts' Motor Trials has been reprinted as a pamphlet, with the addition of Prof. A. B. W. Kennedy's paper on "The Objects and Methods of the Society of Arts' Motor Trials." The pamphlet (price one shilling) can be obtained on application to the Secretary.

CANTOR LECTURES.

The second lecture of the course on "Heat-Engines other than Steam," was delivered by Mr. H. Graham Harris, M.Inst.C.E., on Monday evening, May 13th.

The lectures will be published in the *Journal* during the summer recess.

Proceedings of the Society.

TWENTY-FIRST ORDINARY MEETING.

Wednesday, May 15th, 1889; Edward C. Robins, F.S.A., Member of the Council, in the chair.

The following candidates were proposed for election as members of the Society:—

Forrest, Alexander, Gleniffer-villa, Gibson's-road, Heaton-moor, Stockport.
Mildmay, Henry Bingham, 46, Berkeley-square, W.
Myers, Asher Isaac, 2, Finsbury-square, E.C.
Stanton, Major-General Frederick Smith, The Grove, Hillingdon, Uxbridge.
Trench, Gilbert Kennedy, 11, Townley-park-villas, Dulwich-rise, S.E.

The following candidates were balloted for and duly elected members of the Society:—

Craven, John, Smedley-lodge, Cheetham, Manchester.
Elford, Thomas, Landore Copper Smelting Works, near Swansea.
Halder, Albert H., 10, Throgmorton-avenue, E.C.
Poole, D. Lewis, Bedford-chambers, Southampton-street, Strand, W.C.
Rose-Innes, John, B.Sc., King's College, Cambridge.
Suffield, Lord, K.C.B., 6, Chesterfield-gardens, W., and Gunton-park, Norwich.

The paper read was—

ON THE STREET AND RAILWAY TRAFFIC OF THE METROPOLIS.

By J. Stephen Jeans.

I have undertaken to speak to you to-night on a subject that is of very great importance to the metropolis—second only in importance to the problems that are associated with the supply of our food and clothing. The means of transport from their place of domicile to their place of business have become as essential to a large part of the population of London as their business itself. As London spreads outwards this necessity will become more and more felt, and in course of time it will become imperative, either to establish large shops, factories, and other places of business in the suburbs—to de-Londonise London, in fact—or to make increased provision for having the artisan population carried over longer distances at a low rate of charge. Unless something is done in this direction, the density of traffic which now so grievously troubles our peace and comfort is likely to increase greatly.

Probably the first thing that strikes a visitor to London for the first time is not the enormous size of the metropolis, for that requires much time and experience to duly appreciate; not the magnificence of our public buildings, for that can easily be equalled, and even surpassed, in Paris, Vienna, and other Continental capitals; not the attractions of our shops and warehouses, for of these London has certainly not a monopoly; not the beauty, uniformity, and architectural grace of our streets, for in

these elements we are still much behind; but the extraordinary extent of the vehicular and pedestrian traffic, which, from early morning until midnight, in an unbroken stream, passes along our principal thoroughfares. From the knifeboard of an omnibus, or from the seats which have superseded the original form in the newer vehicles, one can witness in the Strand, Oxford-street, Regent-street, Holborn, and Cheapside, not to speak of many other streets almost equally crowded, a volume and a continuity of traffic of every description which is the distinction of the British metropolis *par excellence*, and which provides with a never-ending theme of wonder and remark the "stranger within our gates."

It is the extent and character of this traffic, and the provision that has been made, and is still being made, for meeting its requirements, that we have undertaken to consider on the present occasion. The subject is a vast one, and its consideration leads us into so many by-paths, that I am much afraid my paper will be more discursive than I should like it to be, and will hardly succeed in focussing the lessons to be taught, and the points to be kept specially in view, so effectually as I should desire. But we can hardly bring ourselves to deal with such a fruitful subject as this, however perfunctorily, without drawing forth some suggestions of practical utility.

The subject naturally divides itself into the three main divisions of the growth of the street and railway traffic of the metropolis, the present extent of that traffic, and the provision necessary to be made for its development in the future. Incidentally we shall have to glance at the changes that are threatened or in course of accomplishment, in the conditions under which it is carried on.

The possibilities of London are difficult to measure. Given a present population of 4,500,000, an increase of upwards of 500,000 every ten years, and the extent and requirements of London a century hence would not be easy to imagine, far less to estimate, for we should then have a population of 10,000,000 souls, or more than the total population of England and Wales in the year 1811. The number of dwelling-houses in the metropolis has increased from 207,000, of an annual value of £12,000,000, in 1870, to 320,000, of an annual value of about £19,000,000 in 1886. Within the last ten years the rateable value of the metropolis has increased by over £10,000,000 sterling. London consumes about 10,000,000 tons of coal, 26,000,000 pieces, and 144,000 loads of timber, contributes £10,500,000 annually to the Customs revenue of the country, imports merchandise of the value of £140,000,000, and exports goods of the value of between £50,000,000 and £60,000,000 every year. About 20,000 new houses, and 300 to 400 new streets are built in the metropolis annually, and in some recent years the length of the new streets and squares built has exceeded 86 miles per annum. More than 400,000,000 letters are delivered in, and more than 15,000,000 of telegrams are forwarded from, London annually. A capital of about £24,000,000 has been expended in providing London, with gas and water. The number of people in the metropolis in receipt of pauper relief is about 900,000, and nearly £2,500,000 is annually expended upon their maintenance. To provide for this vast population of poverty-stricken and unfortunate persons, 39 workhouses, 21 infirmaries and sick asylums, and 22 schools are kept up, with an average of 51,700 inmates daily. For the education of the poorer classes of the metropolis, an annnal expenditure of about £500,000 is incurred by the School Board, and for this and other local purposes, the inhabitants of London have to pay taxes to the amount of about £4,000,000 a year. The cost of provisioning the metropolis, and the quantities of victuals of all kinds consumed by the inhabitants puts the commissariat of the largest army that was ever put in the field entirely in the shade. About 600,000 sheep and lambs; 100,000 oxen, bulls, and cows; 13,000,000 quarters of wheat, and more than 20,000,000 quarters of other cereals; 600,000 cwts. of bacon and ham, 300,000 cwt. of salted and fresh beef and pork; 500,000 cwt. of fresh mutton; 330,000 cwt. of butter; 250,000,000 cwt. of rice; 500,000 cwt. of fish; and 220,000,000 lbs. of tea, with other commodities in proportionate quantities, are brought into London every year by sea, not to speak of the enormous supplies obtained by railway from our own agricultural centres.

Figures, which are ordinarily unattractive, are necessary to enable us to appreciate the extent of the metropolis. It is well that we now say something as to its growth. There is, as we all know, nothing more portentous and phenomenal than the growth of London during the last century, and especially during the last thirty or forty years. At the accession of James I., London was estimated to contain only about 150,000 inhabitants, and for many

years before and after this period, the principal means of moving about from place to place was the water communication afforded by the River Thames, supplemented by the sedan chair. At the beginning of the present century, the population of London was still less than 1,000,000. In 1841 it had not yet reached 2,000,000; and twenty years later it had grown to over 2,800,000. At the census of 1881, the population of the metropolis was returned at 3,816,000, and at the present time, assuming an average annual increase of 50,000, the population must be, in round figures, about 4,250,000. Supposing that the recent rate of growth be maintained, London may easily, in the course of another half century, possess a population of over 7,000,000. Nor is there any reason to suppose that there will be any serious decline in the rate of growth. A recent writer has observed that "overgrown London resembles nothing so much as the loadstone mountain in the Oriental tale. For successive generations, but more especially for the last fifty years, it has been exercising an ever-increasing power of attraction on the entire population of the islands. We need hardly say that the construction of railways gave this centripetal movement an immense impulse, nor need we add that the natural and inevitable results have been largely to modify the national character."

The passenger traffic of London is, of course, mainly in the hands of the railway companies, the six principal lines serving the metropolis in this regard carrying annually over 200,000,000 of people. The tramway companies carry unitedly some 150,000,000 more, and the London General Omnibus Company, and the London Road Car Company (who divide between them the lion's share of the 'bus business), carry from 120,000,000 to 130,000,000 per annum additional. The three agencies together, therefore, carry annually some 460,000,000 to 470,000,000 of passengers, being nearly 12 times the present population of the United Kingdom. But besides the provision made for passenger transport by railway, omnibus, tram-car, and river steamer, there are in London some 11,300 cabs, which carry 80,000 to 85,000 passengers, or, roughly, some 30,000,000 per annum. In other words, if the use of cabs were limited to the population of London alone, each inhabitant would be found to employ a cab seven times in the year, and when the enormous floating population of London is considered, this does not appear to be by any means too large a figure. This vast traffic is, of course, carried on in the public streets, and is increasing daily. The time is now come, and is likely to continue, when the people of other countries, and more especially our "kin across sea," come to London for pleasure, where they formerly came only for business; they now visit us from choice, where they used to see us only from necessity. As London is made more attractive the tendency will doubtless be found to increase. The traffic of our pleasure-seeking visitors, already large, will be much greater than ever, and will assist that created by the natural growth of population, in rendering our chief public thoroughfares all but impassable.

All this is very different from the experience of our forefathers, whose means of locomotion were of the scantiest kind.

Stow states that, "in the yeere 1564, William Boonen, a Dutchman, became the queen's coachman, and was the first that brought the use of coaches into England. After a while, divers great ladies, with as great jealousie of the queen's displeasure, made them coaches, and rid in them up and down the counties, to the great admiration of all beholders."* It appears, however, that Sir Philip Hoby had his "coche" in 1556, and offered to send it to conduct Lady Cecil to Birham. At one of the first audiences which Queen Elizabeth gave La Mothe Fénélon, the French ambassador in 1568, she entertained him with an account of the *douleur* which she experienced in riding in a coach.† Sir Thomas Gresham, speaking of the Duchess of Parma at Antwerp, in 1561, remarks that "the Regent ys still here, and euery other day rydes abowght this towne in her couche, *brave come le sol*, trymmed after the Itallionne fasshone."‡

The idea of the omnibus is ascribed to Pascal, and the first were run in Paris as far back as 1662. In that year it was decreed by a Royal edict of Louis XIV. that a line of *carosses à cinq sous*, each containing eight places, should be established for the benefit of those who required speedy conveyance from one part of the city to another, and were unable to afford a hired carriage for themselves. These *carosses* were bound to run at fixed hours from one station to another,

* "Chronicle." Ed. 1631, p. 867.

† "Dépêches de la Mothe Fénélon." 8vo., 1838, vol. i., p. 27.

‡ Burgon's "Life and Times of Sir Thomas Gresham," vol. i., p. 305.

whether full or empty. The public inauguration of the new conveyances was the occasion of a grand *fête*, and the novelty of the carriage was so great that for a time they were monopolised by the wealthier classes. But the rage for them died away, and it was found that those for whose special benefit they were instituted made no use of them. The result was that they gradually disappeared, and were not revived in Paris until 1827, when they were started in their present form.

It was not until July, 1829, that the omnibus first appeared in the streets of London. It was introduced by a coach proprietor named Shillibeer, and for some time afterwards these conveyances were known as "Shillibeers," an epithet still, or until very recently, in common use in New York, but now only applied in this country to a combined hearse and mourning-coach. Ten years after their appearance in London, viz., in 1839, omnibuses began to run in Amsterdam, and since then they have been in use, in one form or another, in all the chief cities of Europe and America.

Even up to the commencement of the present century the number of public conveyances employed in our streets was very limited. The condition of the streets did not, as a matter of fact, admit of a very general use of carriages or other wheeled vehicles. The records of travel in those days supply innumerable instances of the "hairbreadth 'scapes" to which those who trusted themselves to wheeled conveyances were liable. "Going on circuit" was in those days an undertaking of the most arduous kind, and the cost of transport was so high that only a very small proportion of the population could afford to use it. The majority of the population of London—then still under 1,000,000—made use of the river or walked on foot.

Although the omnibus system became general about the year 1855 to 1860, the tramway system is of a much later date. So recently as 1876 there were only some 94 miles of tramway open in England and Wales, whereas now the mileage open is nearly ten times that figure. The Hansom cab, "the London gondola," is also a modern creation, the first vehicles of this description having been introduced at a comparatively recent period. The first patent was taken out by Mr. Hansom in 1834.

In view of the vast extent, importance, and utility of the railways that belong to the metropolitan system proper, it is difficult to believe that it was not until 1853 that Parliament sanctioned the first section, which was described as a line to run under the New-road from Edgware-road to King's-cross. So far back, however, as 1846, a Royal Commission was appointed to inquire into and report upon certain schemes for railways proposed to be constructed in and around the metropolis. That Commission strongly recommended that any lines to be constructed in the metropolis should be laid out in accordance with a uniform plan, and that Parliament should refuse to sanction separate schemes, brought forward at different times, and without reference to each other. This report had an important influence on the future of metropolitan railway communications. It has been the means of giving us the admirable system of underground communication that we now enjoy, and of securing whatever unity of purpose and comprehensiveness of plan that system can claim. In 1854 Parliament sanctioned an extension of the Metropolitan Railway from King's-cross to the Post-office. The metropolitan line as a whole was not, however, completed until 1864, and the District Railway soon followed, providing the inner circuit that has enabled communication to be opened between nearly all parts of the metropolis. The Blackwall and the London and Greenwich Railways are of much earlier date. The former line was carried out in 1837, and in 1839 the company obtained an Act for an extension to Fenchurch-street. The Act for the Greenwich Railway was obtained in 1833, and the line was opened in 1837 to Deptford, but in the following year it was extended to Greenwich.

In 1853, a Committee of the House of Commons made an important recommendation, which has hitherto not been acted upon, although of vital consequence to the metropolis. They proposed that the different metropolitan termini "should be connected by railway with each other, with the docks, the river, and the Post-office, so as to accelerate the mails, and take all through traffic, not only of passengers, but, in a still more important degree, of goods, off the streets." They added that "it is desirable that railway communication, where it does not already exist, should be established between the various main lines of railway." This proposal, after a lapse of thirty-five years, is likely shortly to be realised by the construction of the Outer Circle Line, which is intended to connect the Great Western, the London and North-Western, the Midland, the Great Northern, the Great Eastern, the South-Western, the Metropolitan, and the District lines of railways, with each other, and with the

East and West India, the London and St. Katherine (including the Victoria and Albert), the Millwall, and the Tilbury Docks.

The most limited glance at the passenger traffic of London railways could hardly fail to take account of their enormous cost and their large and rapidly extended traffic and income. To illustrate these phenomena, it may be sufficient to compare the years 1875 and 1886, which, as regards capital cost, is done in the following Table :—

CAPITAL EXPENDITURE ON METROPOLITAN LINES.

Name of Railway.	1875.	1886.	Increase in 1886.
	£	£	£
Metropolitan	8,053,000	11,329,084	3,276,084
Metropolitan District	5,493,846	7,335,519	1,841,673
North London	3,815,866	3,941,266	125,400
London, Tilbury, & Southend	830,650	2,257,268	1,426,618
London, Chatham, & Dover	21,572,273	26,493,481	4,921,208
London, Brighton, & South Coast	19,183,056	23,361,311	4,178,255
Totals	58,948,691	74,717,929	15,769,238

Although there has been no new company started, and no very remarkable development of extent over this period, the capital has increased by £15,750,000 sterling. That expenditure has, of course, been incurred on extensions of a minor character, and in providing additional facilities of every kind, rendered necessary by the phenomenal increase of traffic. That increase of traffic has, moreover, applied alike to passengers and to goods. As regards the former, the figures compare as under :—

NUMBER OF PASSENGERS CARRIED ON LONDON RAILWAYS.

Name of Railway.	1875.	1886.	Increase in 1886.
Metropolitan	43,614,000	70,694,000	27,080,000
Metropolitan District	25,856,000	41,274,000	15,418,000
North London	20,877,000	29,244,000	8,367,000
London, Tilbury, and Southend	2,083,000	5,282,000	3,199,000
London, Chatham, and Dover	20,633,000	27,797,000	7,164,000
London, Brighton, and South Coast..	25,411,000	36,152,000	10,741,000
Totals	138,474,000	210,443,000	71,969,000

So far as goods traffic is concerned, the figures for the same period compare as under :—

NUMBER OF TONS OF GOODS TRAFFIC CARRIED ON LONDON RAILWAYS.

Name of Railway.	1875.	1886.	Increase in 1886.
Metropolitan	1,284,000	1,613,000	329,000
North London....................	1,791,000	2,351,000	560,000
London, Tilbury, & Southend	75,000	312,000	237,000
London, Chatham, & Dover .	1,466,000	2,195,000	729,000
London, Brighton, & South Coast...........................	1,687,000	2,347,000	660,000
Totals	6,303,000	8,818,000	2,515,000

The really practical part of the problem which we have undertaken to consider this evening is—How shall we economise space and time, and minimise the now serious, and steadily increasing dangers of the public streets for those who are compelled daily to travel to and fro in this great metropolis. The increase of street traffic, measure it by whatsoever standard we will, is amazing. Take the case of the General Omnibus Company alone. Between 1880 and 1887, the Company increased the number of passengers carried, from 56,000,000 to about 100,000,000, and advanced the number of miles run, from 13,000,000 to to 18,000,000 per annum. The increase in the number of passengers, relatively to that in the mileage run, is a clear proof that the omnibuses have been much fuller than they were—due, no doubt, to the reductions in the fares that have been made from time to time. The extent of the reduction is apparent from the fact that, in 1880, the average fare per passenger amounted to 2·39d, whereas in 1887 it was only 1·72d, showing a decrease of nearly 30 per cent. In the same period the average earnings per mile run have been reduced from 10·38d to 8·99d, but the dividends paid have remained about the same.

One very remarkable characteristic of the modern system of transport, whether by road, rail, or river, is its exceeding cheapness. The old-fashioned system of transport was roughly founded on the basis of a shilling for every mile travelled, whether by a passenger, or by a ton of merchandise. At this rate, travelling was necessarily limited. The total number of third-class passengers who travelled on the railways of the United Kingdom in 1887 was 638,250,000, and as the average amount paid

to the railways per third-class passenger was about sevenpence, it would appear that the 638,250,000 of passengers travelled a total distance of about 4,450,000 of miles. If the average payment made by the people had been the same as in the days to which we refer, this transport would have involved a cost of about £220,000,000 sterling, instead of the £18,293,000, which was actually paid to the railway companies. The average payment per passenger on the omnibuses and tramway cars of the metropolis does not much exceed 1d. per journey, and for this humble coin, the traveller may make a journey from Victoria Station to Charing-cross, from Charing-cross to Liverpool-street, and from Piccadilly-circus to Kensington Church. In each of these cases the travelling is not much over one halfpenny per mile. It is this cheapening of the means of transport that has so enormously extended its development. It is noticeable that it is the cheapest traffic that has chiefly extended. On the Metropolitan District Railway, for example, the total number of passengers carried, in 1872, was 20,098,000, of whom 2,253,000, or 11 per cent. were first-class. But in 1887, while the total number of passengers carried on the same line had increased to 36,577,000, an increase of about 80 per cent. in sixteen years, only a little over 8 per cent. were first-class. The tendency has been, in London as in other large centres of population, to increase the third-class travel at the expense of the first and second-class. It is a matter for regret that our railway companies, who depend so much upon their third-class traffic, do not endeavour to make better provision for it than they do on our southern lines. They manage things much better in the Midlands and in the North.

My friend, Mr. Greathead, M.I.C.E., the engineer of the new subway from the monument to Kennington, has favoured me with a diagram to which I would call your attention, which shows in graphic form the immense increase that has taken place in the passenger traffic of the metropolis, between 1862 and the end of 1884. It will be observed, as regards the General Omnibus Company, which was constituted in Paris in 1855, that there was very little increase of traffic between 1862 and 1874, when the fares took a high range; but when the competition of the tramways and of the underground railways compelled a reduction of fares, the traffic increased, and between 1879 and 1884, when the average fare was reduced from 2·4d. to 2·07d, there was an increase of not less than 28 per cent. The same law of increase is shown in the case of the traffic of the tramway companies, which, between 1874 and 1884, reduced their average fare from 2·04d. to 1.55d. I also show diagrams illustrative of the growth of traffic on the Metropolitan and Metropolitan District Railways, and of the traffic of New York City, which, relatively to population, is strikingly great.

The following statement shows approximately the numbers of passengers transported in London in 1887, and the sums for which they were carried:—

	Number of Passengers.	Passenger Receipts.
		£
Metropolitan Railway	67,305,000	581,319
Do. District do.	36,578,000	385,199
North London do.	29,147,000	301,507
Tramway Companies	145,902,000	854,130
London General Omnibus Co.	93,000,000	634,000
Cabs, &c.	30,000,000	2,250,000*
Totals	401,932,000	5,006,155

In addition to these figures, very large numbers of passengers are carried daily to and from the suburbs by every railway that has a terminal station in the metropolis. Probably the numbers so carried will, in the aggregate, nearly double the numbers shown above to be carried by railway, making, roughly, 100,000,000 to 120,000,000 more, and bringing up the total numbers carried annually, into and out of London, to between 490,000,000 and 500,000,000.

The conditions under which the passenger traffic of the metropolis is now carried on is likely to be greatly modified before long, in consequence of the extended use of electricity as a motive power. My friend, Major Flood Page, in a recent letter to the *Times*, indulges the hope that, "before many years pass over our heads, we may see the Metropolitan and the District Railways entirely worked by electricity." He gives good reasons for this belief. Lord Bury's Company have undertaken to make experiments with electricity on the Metropolitan line, and Messrs. Mather and Platt have undertaken the construction of

* The average fare has been taken at 1s. 6d., but this is only an estimate, as there are no reliable returns at command.

a complete electric railway for working the traffic in the City of London and Southwark Subway, where it is proposed to run some 2,200 trains per day. Electric railways and tramways have now passed beyond the region of mere experiment. They have been worked successfully for years at Brighton, Blackpool, and other places, and even electric omnibuses have been found to answer without any auxiliary horse-power. It would be absurd to suppose that we shall "rest and be thankful" at the present stage of the electric power question. There are, no doubt, difficulties still to be overcome; but the feasibility of the use of electricity for propulsion of almost any description has been proved, and that is three parts of the difficulty overcome. Besides, the electric world is now in real earnest. During the last twelve months the movement for lighting London by electricity has advanced by bounds, and the future of the system, which looked far from promising four or five years ago, has entered upon a new and much more successful phase. The system appears to be specially suited to tramway working; and at the last half-yearly meeting of the Metropolitan Tramways Company it was announced that, by this time, the Barking line would be run entirely by electricity. Engineers and others will watch with the keenest interest for details of the cost of electricity in comparison with horse-power.

Three important projects are at the present time either in course of execution or contemplation for the purpose of relieving the congested traffic of the streets of the metropolis. They are—

1. The Metropolitan Outer Circle Railway.
2. The City and Southwark Subway.
3. The proposed railway from Piccadilly to Holborn-circus.

The object of the first undertaking is, by an independent line, in the hands of an independent company, to connect all the different railways that surround London, not only *inter se*, but also with the system of docks at the east, and especially at Tilbury.

The second undertaking, which is likely to be opened in August or September next, will afford a means of communication between the City—by a station near to the Monument—with the south side, the other terminus being in the neighbourhood of Stockwell.

The third project for which Parliamentary sanction is now being sought has for its object to establish a line of communication between Piccadilly and Holborn by two small tunnels, each 8 ft. 2 in. wide, for railway trains to be worked by electricity, and two parallel galleries for pipes and sewers.

The latter undertaking, while it would undoubtedly be a great relief to the crowded streets in the region of its two termini, would involve the excavation of a very considerable subsoil, and the reconstruction of a vast network of pipes and sewers. Most of the work would probably require to be done at night, and for this reason it would be likely to be extremely costly. In the case of the City and Southwark Subway, however, most of the work has been done by tunnelling, and has been quite unattended by any inconvenience with the traffic. Both lines would be worked by electric motors, and therefore, although underground, the ventilation would not be likely to interfere with their success.

Another project has been talked about, the object of which is to have a railway constructed between Westminster and the Edgware-road, but it has not heen regarded with much favour.

There are strong objections to the increase of underground ways of communication in London. It is, no doubt, the fact that wherever the underground railway penetrates property depreciates in value, except, perhaps, for business purposes in the immediate neighbourhood of railway stations. The vibration, which is an accompaniment of the proximity of a railway, does not tend to improve the value of buildings for residential purposes, and any one who cares to examine into the facts will find that there are many more houses untenanted along the line of the underground railways than anywhere else in London. In South Kensington, and in other districts where houses of the best class are to be found, the depreciation of property due to this cause is enormous, although the gross rateable value of the metropolis as a whole is steadily increasing, and amounted for the last financial year to £37,700,000. If a railway were carried through from Westminster to Oxford-circus, as was at one time intended, the loss to the owners of property along the line of route would be likely to be serious.

Assuming that the increase of our railway facilities in the centre of London would be attended with inconvenience, and would be met with a great deal of opposition on the ground of interference with vested interests and depreciation of property, we have to face the inevitable alternative of an extension of the traffic which is already rendering many of our principal streets almost impassable. There

has recently been an extraordinary multiplication of the omnibus, road car, and cab traffic of the metropolis, and it is still growing. Of course, this traffic may be regulated in such a way as to practically provide for doubling, trebling, or even quadrupling it. The streets may be widened; or traffic may be allowed to go in one direction only, so that all vehicles going east might keep the Embankment, and all going west take the Strand; or heavy traffic, such as lorries, vans, &c., might be excluded from the main thoroughfares except at certain hours in the morning. These are only a few of many suggestions that might be put forward with this end in view.

Incidentally I may refer to the serious trouble and delay that is created from time to time by the accidents to horses employed in our street traffic. There is no motor so pliable, so convenient, and so fully under control as the horse. He adapts himself to the varying requirements of the crowded streets, as no merely mechanical motor can be expected to do, gyrating amid the stream of traffic in a way that excites the wonder and the admiration of the onlooker. The number of horses employed in carrying on the street traffic of the metropolis must be very large. There are, to begin with, more than 11,300 cabs, employing, perhaps, double that number of horses. Then there are the horses employed in tramway working, which, according to the latest returns, numbered nearly 9,000; and the horses engaged in working the omnibus traffic, which may be put at some 15,000 more. Finally, there is the vast army of horses engaged in the transport of coal, provisions, and general merchandise, required to meet the needs of a population that numbers close on 5,000,000. Of such horses the number must be extraordinarily large, although it is difficult of exact computation.

Among the means that have been suggested for the amelioration of the mode in which these horses are engaged, none seem to me to be of greater importance than that of providing them with shoes that are anatomically adapted to the foot, and no system or suggestion put forward with this end at view is at all comparable, so far as I can learn, with the nailless horse-shoe that has recently been attracting attention in London and the provinces. The ordinary horse-shoe is in many respects defective, and it is liable to cause pain to the horse, to incite to slipping on our wooden streets, and to consequent accidents, while in the matter of anatomical accuracy it leaves a good deal to be desired. A skilled farrier will tell us that, as horses are now shod, the hoof of the animal is held by the nails, and has no room for expansion, whereas the tendency of the nailless shoe is to give the hoof free play, with the frog coming directly upon the ground, while the form of the under part of the shoe is such that the horse has a better grip upon the road. This must be a matter of considerable importance to the 17,500 horses now employed by the tramway and general omnibus companies, not to speak of the horses employed in Hansom-cab traffic, whose numbers are legion, and who, in frosty and muggy weather, are continually "coming to grief." Then, again, how greatly is the misery of street transport aggravated by a loose shoe, or by the casting of a shoe, to which horses are so much liable. The new nailless horse-shoe is so constructed that india-rubber or gutta-percha may be inserted at various places in the lower part of the shoe, and slipping would thereby be reduced so considerably, that the serious interference to traffic that now results from a fallen horse would be greatly mitigated. Not only so, but the owners of horses, whether companies or individuals, would benefit greatly by being able to shoe their horses themselves, which may easily be done by the new system, and the working lives of the animals would be prolonged in the absence of "pricking," now so common by the old-fashioned system. If horses are to be still our chief resource for street transport, as no doubt they must be, it is important that everything should be done to reduce the cost of their maintenance, and to lengthen their days, and the nailless horse-shoe will be found to exercise in both directions an influence that will be appreciably felt.

One of the most obvious and effective plans that occurs to me of mitigating the difficulties which are at the present time incidental to the street traffic of London, is that of taking steps to give effect to the recommendation of the Select Committee of 1853, that a connection should be made between the different metropolitan termini. The scheme of a vast central station in the heart of London, giving access to all parts of the kingdom, is perhaps Utopian. It is difficult to imagine a structure that would represent the united dimensions of St. Pancras, Euston, King's-cross, Liverpool-street, Victoria, and half-a-dozen other terminal stations rolled into one. But a great deal is practicable in the way of bringing the railways on the north and south of the Thames into closer intercourse with each other. If this were done, if the traveller could get to his

intended destination by railway equally well from the same common centre, whether he were going north or south, east or west, there would be a great diminution of the traffic in our main thoroughfares, and the expenditure on travelling would be much less than it is.

There is, moreover, a great deal to be done in the way of economising the delivery of traffic at the doors of the consumers. The docks of London receive from and send out to all parts of the world some 20,000,000 tons of traffic of all kinds every year. The great bulk of the traffic, under existing circumstances, has to be carted to or from the doors of the consigners or consignees. The distance of the greater part of the metropolis from the docks in the East-end is so considerable, that the charge made for the carriage of a unit of traffic by van or lorry, say three or four miles, is often greater than the charge made for the transport of the same unit across the Atlantic. The traffic of all kinds brought into the London docks by sea, amounts to some 12,000,000 or 13,000,000 tons a year. All the traffic has to be distributed by road or rail. Nearly the whole of it has to be carried some distance before it can be put on to the railway. The average charge for the delivery of traffic between the steamer in the docks and the home of the consumer will probably not be less than 10s. per ton, so that fully £6,500,000 to £7,000,000 sterling is appropriated to this purpose.

The same observations apply to the delivery and collection of goods by the railway companies. Owing to the almost entire absence of suitable connections between the different railways, and their failure and possible reluctance to adopt working arrangements in the interests of the public, the traffic that would otherwise be put upon the railways direct has now to be carted through the public streets, increasing the block of vehicles, the cost of transport, and the inconvenience and discomfort of everybody.

There is no excuse for a great deal of the trouble that is entailed by the present system. Whether the traffic is sent down the river to a great terminal station, where it would be distributed to the different railway companies who are charged with its delivery, or whether it is to be sent round the suburbs by some such line as the proposed Metropolitan Outer Circle Railway, or whether it is to be handled in some other way, there is no reason why the time of business men should be seriously wasted, and the dangers of the streets enormously increased, by the heavy traffic that may now be seen lumbering along our main roads at all hours of the day and night.

There is, as we have already indicated, a prospect that before long we shall see other means of transport largely taking the place of horses on our principal tramway and omnibus routes. The tram-cars of the North London Tramway Company are already worked by steam power, the number of engines that they employed at the end of 1887 being 27. Others, again, such as the Highgate-hill Tramways, are worked by stationary engines; still others, like the Barking line, are worked by electricity. Compressed air is a fourth system that may very possibly be adopted in the future. Whether these systems, when they become more extended, will increase the safety of our streets, is very doubtful. A horse is usually quite as manageable as a steam-engine on a public road, and perhaps even more adaptable. You may stop a steam-engine, but you cannot so readily turn it aside as you can a team of horses, so that the unlucky pedestrian who happens to get in immediate front of a steam-propelled vehicle has not ths same chance, unless it is stopped dead, of getting off scatheless.

It is necessary to bring home to the public sense the increasing danger of our public streets, and I have been favoured by Mr. Munro, the Chief Commissioner of Police, with a statement showing the numbers of persons killed and injured on the streets of London in each of the years 1867, 1877, and 1887. This record shows that the dangers of our public thoroughfares are greatly on the increase, and that they are, in point of fact, very little behind those of railway travelling. The proportions killed, and maimed or injured, in each of the years named were—

Year.	Nos. killed.	Nos. maimed or injured.
1867	96	1,284
1877	120	2,836
1887	142	4,567

On analysing the returns that show the descriptions of vehicles that have caused these accidents, we find that, as regards the year 1887, the principal offenders were as under:—

Description of vehicle causing accident.	Nos. killed.	Nos. maimed or injured.
Cabs	14	1,051
Omnibuses and cars	19	449
Broughams and carriages	3	403
Light carts	19	1,290
Waggons and drays	13	131
Vans	52	847
Heavy carts	13	142

We are here able to put our finger on the worst offenders of the lot. It is the swiftly-driven light van of the butcher, the baker, the grocer, and other tradesmen that has chiefly to answer for the terrible injuries that so frequently attend the conduct of our street traffic. By comparison, the cab and the omnibus are almost trivial offenders. There are probably few of us who have not experienced "hairbreadth 'scapes" from this source, and probably, also, most of us have had a strong desire to bring to summary justice these disturbers of public peace and safety. The dangers of the streets from this point of view is aptly illustrated by an anecdote which is told of a candidate for admission into a homicidal fraternity, whose members were only qualified after they had been guilty of murder or manslaughter. This candidate was asked the usual question, "Have you killed your man?" "I have," was the ready reply. "How was it done? by shooting?" "No." "By stabbing?" "No." "By poison?" "No." "How then?" "I drove a butcher's cart," was the final and sufficient rejoinder. Seriously, I commend to the consideration of the Home-office and Scotland-yard the growth of this evil; and I believe that few of us would regret if every light van that is found crossing a street or turning an angle, except at a walking pace, were put under arrest. It is far from satisfactory to find that the number of persons maimed or injured by these light vans has increased from 510 to 1,290 between 1867 and 1887.

Although I have not undertaken to deal with ordinary merchandise traffic, I may observe that the coal traffic of London alone is one of the largest items in the history and mechanism of the means of transportation. The total quantity of coal now annually handled within the limits of the metropolis is upwards of 12,000,000 tons per annum. Within the last thirty years the coal consumption of the metropolis has more than doubled, and at the present time it exceeds the total quantity of coal raised in the United Kingdom less than a century ago. The Table (next column) shows that when we can get accurate statistics of the consumption of coal we find the increments indefinitely increasing, in the manner rather of a geometrical than of an arithmetical series.

It is manifest that if the same rate of increase is maintained over the next fifty years, the handling of this enormous traffic within so limited a radius will present for solution problems of the deepest interest and not improbably of great difficulty. Already, as we know, some of the London railways have much trouble with their coal trains. Every day passenger trains are delayed and put to inconvenience by the slow motion of the mineral traffic, and unless separate lines be provided for each, which would, of course, involve the doubling of many central stations, like that of Ludgate-hill, Snow-hill, &c., the evil is likely to increase.

Year.	Total quantity of coal imported into London.	Increase in Fifty Years.
	Tons.	Tons.
1650	216,000	—
1700	428,100	212,100
1750	688,700	260,600
1800	1,099,000	410,300
1850	3,638,883	2,539,883
1863	5,119,887	—
1888	12,518,000	—

In conclusion, I would observe that I have, of necessity, done little more than touch the fringe of this great subject. We have seen that within twelve years the increase in the number of passengers carried on the six metropolitan railways that chiefly deal with local traffic has been about 72,000,000, without including the increase in the number of journeys made by season-ticket holders, which would probably bring the increase up to about 100,000,000, or roughly speaking, twenty times the entire population of Greater London. Is this increase likely to be continued? If it is, how is it likely to be provided for? The limits of carrying capacity possessed by the principal metropolitan lines have already been almost attained—not throughout the whole day, but during the hours when the suburbs are pouring their millions into the City, and when the same millions are returning to the suburbs. And this must necessarily be the measure of the capacity of our local railways. If the period should come when no more passengers can be carried with safety at certain hours, the time will also have arrived when the public will seek for other means of transport. In the near future such additional means of transport will have to be provided in any case. What are those means to be? Underground travelling has no charms for the majority of travellers. If a quick, expeditious, and agreeable system of travelling in the open could be contrived, the

railways that now burrow our streets and public places would be relieved of a great part of their traffic, and the public comfort and convenience would be promoted. What is especially wanted is the establishment of several services of tram-cars and omnibuses, or, perhaps, overhead railways, that will afford quick transport to the centre of the city and important terminal points in the suburbs. We require *petite vitesse* and *grande vitesse* applied to our street traffic, with differentiating scales of charges. Already this system is partially in operation. The omnibuses that run from West Kensington to Piccadilly-circus, or from Clapham and Brixton to the City, are usually so full at certain hours of the forenoon and afternoon, that they cannot stop, *en route*, to take up any more passengers, and their journey is thus made, as a rule, at a good pace. But woe betide the unfortunate who has to travel by the same conveyances during the rest of the day. The halts that they make are legion, and the continual passing and re-passing of passengers is enough to try the sweetest temper. I think the whole subject is one that it would be well worth the while of the Society to consider in conference, and it would not be amiss to offer prizes for suggestions as to the best means of mitigating the evils that now beset our street traffic—whether by new systems of transport, by additional lines of railway or tramway, or by other means which must be well within the limits of the practicable.

DISCUSSION.

Major FLOOD PAGE said it was absolutely impossible for anyone, without having studied the paper, to follow the mass of figures which had been put before them. Although there was room for vast improvement, he thought Londoners might congratulate themselves on the admirable manner in which street traffic was conducted. The regulation of London traffic bore a very favourable comparison with that of Paris. The way the London police regulated the traffic was most admirable, and he should have been glad if the reader of the paper had stated whether the increase of accidents was in excess of the increase of population. Everyone would agree in the remarks that butchers' carts ought to be made to go at a more moderate pace, and he hoped the Society of Arts would draw the attention of the police to this evil. Mr. Jeans had alluded to the fact that it was proposed to work the City and Southwark Subway by electricity, and he hoped he was not too sanguine when he stated that the mode of dealing with the traffic of the streets would depend upon the use of electricity. He was in conversation that day with a member of the firm who were going to work the subway with electricity, and this gentleman stated that his firm were well in advance of the work; that they would be able to deliver the machinery as soon as the subway was ready for work. The contract involved the working of a three-minute service, and no less than 2,300 train miles a day would be worked by means of electricity. The mere working of tramways or railways by electricity was a matter which had been so often proved experimentally that those who had to deal with it had no fear of the result. The lighting of the City was also an important matter for consideration, and if the streets were lighted by electricity repairs to the roads might be carried out during the night. Milan was lighted by 450 arc lamps and many million incandescent lamps, and there the streets were repaired at night.

Mr. J. EASTTY said, with regard to locomotion for the working classes, that, considering the bad state of the water-side business, in consequence of the change which has taken place with regard to new facilities given by the docks, and the way the goods were brought by railways to the doors of the merchants, that there would shortly be found a large area for the houses of the working classes by the water side. That was his theory, having watched the water side and its business for many years. He thought the regulation of the traffic of London had rather improved than gone back, and that speed had increased without there being any increase in the nnmber of deaths from accident. He suggested that at different points of the metropolis there should be depôts where the necessary appliances might be obtained for repairing vehicles that broke down, which were a constant source of impediment to traffic. He regretted that reference had not been made in the paper to steamboats as a means of locomotion. So far as he could judge, the rule of the road was better observed in London than in many towns, and he agreed in the suggestion that drivers of light carts ought to be made amenable to the law.

Major TODD suggested that every driver of a light cart or van should be compelled to have a license, and be under the same conditions as omnibus drivers, in which case there was no doubt they would hear of fewer accidents. He also thought that at dangerous crossings of streets boards should be erected stating that the place was dangerous. London seemed very much behind other parts of the country in electric lighting, and it was time that the County Council took up this matter. He agreed with Major Flood Page that roads ought to be repaired at night. It was a disgrace that the traffic of any district should be stopped by the want of a little common sense in managing these things. Another matter worthy of

consideration was the slipping of horses, for when a horse fell down the traffic of the street was immediately stopped. One great cause of horses slipping was due to roads not being properly made, thus causing the subsoil to ooze up, and converting the road into a state of mud. Every four-wheeled carriage should be compelled to have a brake fitted to it. The "Goodenough" shoe was a step in the right direction, although the principle did not go far enough. In his opinion the nailless shoe was simply perfect, as it prevented slipping, in addition to which cruelty to horses was abolished in the farrier's shop.

Colonel KNOWLES said that a very large number of horses were seriously injured, if not killed, by unskilful shoeing, and any improvement which would render the work of horses less toilsome would in the name of humanity be gladly accepted. The nailless shoe was of considerable value from a military point of view. With an ordinary shoe one required a forge and a farrier, which were not always obtainable or desirable in an enemy's country, and any shoe that could be put on by the trooper rapidly was of great importance.

Mr. T. C. TOWNSEND said he would not deal with the question of nailless shoes for London traffic, because it seemed to him that shoes must be secured upon the hoofs in some shape or form, but the point to be decided in his opinion was what shoes were best suitable to the pavement and roadways of London. He had travelled in France, Germany, Belgium, and Russia, at twelve miles an hour, without the horse ever stumbling. This was due to the fact that small steel studs were screwed into the horses' shoes, and he thought it would be a step in the right direction if this was made compulsory in London. If the streets of London were paved with wood, and steel studs inserted in the shoes, slipping would be a thing of the past.

Mr. W. STORR said that the meeting showed very commendable sympathy with horses on account of their preventible sufferings, but he understood the main problem suggested by the paper to be the relief of the crowded streets of central London by improved arrangements for the traffic. A glance at the map showed that one serious problem, as yet very partially solved, was a direct railway communication between the main lines north and south of London. The connections already made accommodated only a small part of the through traffic. Railways that were contiguous without being joined were useless for travellers with luggage and children. There was an immense amount of direct street traffic between Charing-cross and Victoria on one side, and Paddington, Euston, St. Pancras, and King's-cross on the other. Direct and frequent service by railway would afford immense relief to the most crowded streets of London; and it would do so not only by accommodating long distance through-passengers, but also by meeting the needs of London residents, who were often compelled to cross London in vehicles in spite of the supposed convenience afforded by railway connections. It seemed as if in the past metropolitan railways had been laid out with too little regard to the requirements of the majority of people to pass as quickly as possible between centre and circumference. An immense loss of time was imposed upon passengers in taking circular routes when they really wished to get to business or to get home as directly and quickly as possible. This suggested that regard might be had in future to the separation to some extent of two classes of traffic—that which was intermediate, and that which required to pass from point to point without delay.

Mr. CHARLES WHITE considered that the adoption of overhead railways, of the kind used in America, would go a long way towards relieving the streets of their congested traffic. He was in favour of roads being repaired at night, which could easily be done if the electric light was adopted. These were subjects which he thought the County Council should take into their consideration.

The CHAIRMAN, in moving a vote of thanks to the reader of the paper, said he was very glad to hear the remarks with reference to the formation of streets in different directions for getting rid of the traffic from one portion of the town to the other. Some interesting remarks had been made upon the subject of horseshoes and matters of that kind, but the one thing to relieve the traffic was the formation of new streets in better directions. He thought the County Council might do something in this way, and might take as an example what had been done in the City of London, where the whole of the area had been planned out, and improvements dotted down, to be effected as soon as leases fell in. The whole of London ought to be treated in this way, and a map should be prepared by the officers of the County Council, and when opportunity occurred the necessary improvements should be made. Many parts of London were owned by a single landlord, and improvement would be very easy if it could be shown that it would be very much to the benefit of these landlords. A plan of the kind he had suggested might very easily be prepared. In the case of the improvements at Ludgate-hill a plan was prepared many years ago showing how it might be widened, and as the leases fell in the improvements were gradually carried out. It had also been proposed that the church in the Strand should be removed in order to relieve the traffic, though, in his opinion, this was not necessary, a preferable plan being to form another road at the side of the church. Every opportunity ought to be seized as it occurred for increasing the width of the thoroughfares.

The vote of thanks having been carried unanimously,

Mr. JEANS said there was very little for him to reply to. He was a little disappointed that no part had been taken in the discussion by any of the railway managers or representatives of the railway companies, though he had no doubt the paper would come to their notice, and in that way the suggestions made would be considered. Mr. Storr had referred to the fact that the metropolitan outer circle was not likely to relieve the traffic, but he might mention that the main object of this line was to couple up other lines, so that the goods traffic might be taken to the docks without the necessity of break of bulk. He was afraid they could not settle the question of overhead railways in that room, and for himself he confessed to preferring to travel by an underground railway.

APPLIED ART SECTION.

Tuesday, May 14; J. HUNGERFORD POLLEN in the chair.

The paper read was on "Venetian Glass," by Dr. Salviati.

The paper will be printed in a forthcoming number of the *Journal*.

Miscellaneous.

SUGAR IN INDIA.

The following paper, prepared from the official Reports of the Government of India, has been communicated by Sir Charles Bernard, K.C.S.I. :—

For some years past the Government of India have been collecting information concerning the cultivation of sugar in India, and an abstract of that information has recently been furnished. The growth and the consumption of sugar have greatly increased during the past fifteen years. The extension of canal irrigation in Northern India, and the abolition of the internal Customs dues, at which duties amounting to Rx. 120,000 used to be levied on all sugar passing westwards from the Ganges valley, have been among the chief causes of the increase. The diffusion of money by reason of the extension of trade, and the general rise in standard of comfort over a great part of India, have contributed to increase the consumption of sugar, which besides tobacco, is the chief, almost the only luxury enjoyed by the great mass of the population. The area under sugar-cane in India is now quoted at 2,500,000 acres, with a yield of 2,500,000 tons of unrefined sugar, or about one ton of coarse sugar to the acre. Most of the sugar is manufactured on the spot by the petty farmers who grow it; but there are a few factories, as at Aska, in South India, and the Rosa factory in Shahjehanpore of North India, where sugar and its products are refined on a large scale with modern appliances.

The external trade of India in sugar has altered during recent years. In 1850 she used to export Rx. 1,824,000 worth of sugar; in the year 1886, notwithstanding the increased production of sugar, she exported only Rx. 492,000 worth of sugar. In the years 1860-62 she imported Rx. 226,000 worth of sugar annually, whereas India's average importations of sugar during the years 1884-86 were valued at Rx. 1,800,000 a-year. The total consumption of sugar in British India is now about 2,600,000 tons of coarse sugar, valued at Rx. 10 per ton, or about $\frac{4}{7}$ of an anna (or 1d.) per lb. This gives an average consumption of sugar of 26 lbs. (or about $1\frac{1}{5}$ rupees worth) per head of the total population per annum. An average Indian's yearly expenditure on salt, at 12 lbs. per head per annum, would be $\frac{1}{2}$ rupee a year, as against $1\frac{4}{7}$ rupee spent on sugar. According to Mr. A. E. Bateman, of the Board of Trade (p. 286 of the Sugar Convention Blue-book of 1888), the yearly consumption of sugar in other countries comes to 70 lbs. per head in the United Kingdom, 60 lbs. in the United States, 27 lbs. in France, 19 lbs. in Germany, and 9 lbs. in Austria; so India comes out well with her consumption of 26 lbs. per head.

Messrs. Travers and Son, sugar merchants of London, after considering the information recently collected in India concerning sugar, advise that the sugar growers of the West Indies obtain a yield of two tons of properly crystallised sugar per acre; that there is no reason why Indian cane should not yield as much; that the modern mode of preparing refined sugar direct from the cane ought to be extended in India, where the custom is to make first coarse sugar, and then by another process to make refined sugar from the coarse product; that Indian farmers probably do not extract one-third of the sugar that might be extracted from their crops, and that third is very coarse sugar, instead of being "raw sugar properly crystallised by modern processes." Messrs. Travers and Son urge that, with proper appliances and system, India ought to grow all the sugar her people require, ought to import no sugar from the Mauritius, and ought to export sugar largely to other lands, for her soil, her climate, and her irrigation systems fit her for being the greatest sugar-producing country of the world.

GOVERNMENT SCHOOLS IN CHINA.

In 1885, after peace had been declared between France and China, the Viceroy, Li Hung Chang, obtained the Imperial sanction for opening military and naval schools at Tien-Tsin, where Chinese pupils could receive instruction in Western sciences. Consul

Smithers, of Tien-Tsin, says that the military school has been in operation five years, and has 150 pupils. It has four German professors, and the instruction is entirely in the German and Chinese languages. The naval school is divided into two departments—the executive, for the training of naval officers, and the engineering for the training of engineers. The number of pupils is 120, selected from the different provinces of the Empire, and the length of the course is five years. The director of studies is assisted by three English professors, two of whom belong to the English navy. The director himself, Yen Tsung Kwang, is a graduate of the foreign school at Foo-chow, and has served in the navy. A school for instruction in telegraphy was organised in 1880, and at present has forty-eight pupils. The instructors in this school are Danes, but the instruction is given in the English language. A local medical school with a hospital attached was founded some years ago by the Viceroy. This school is now about to be re-organised, with an eminent foreign doctor at its head, the object being to qualify young men for the medical profession, and attach them to the army and navy as well as other branches of the public service. In addition to the schools already mentioned, Consul Smithers, writing under date of the 31st December last, says that an Anglo-Chinese college was to be opened early in 1889. The building for this college was commenced in 1887. It is a fine Gothic structure, situated on the left bank of the Peiho, and has accommodation for 300 students. In conclusion, the United States Consul says:—"When it is considered that hitherto the officers in the Chinese army and navy below the rank of general and admiral have been taken from the uneducated classes, and have obtained their commissions often by purchase, and that both branches of the service have been without a medical staff, the importance of the educational establishments at Tien-Tsin, promoted and fostered by the Viceroy, cannot be over-estimated."

LIVERPOOL WATER SUPPLY.

In presence of the remarkable increase in the population of Liverpool, it became evident long ago that the sources of water supply, hitherto relied upon, were wholly inadequate. Various proposals were made for imitating the action of the Glasgow municipal authority, by leading the water from one or other of the lakes; but the project of Mr. G. F. Deacon, formed in 1877, of employing for the purpose the site of an ancient lake in North Wales, was ultimately adopted.

The position is an alluvial tract at the head waters of the River Vyrnwy, a tributary of the Severn, in Montgomeryshire, and in the centre of a triangle formed by the towns of Bala, Dinas, Mowddwy, and Llanfyllin, distant from Liverpool 45 miles in a direct line, but, along the aqueduct, 68 miles to the Prescot reservoirs, 77 miles to the Town-hall. The evidence that this valley was the site of a post-glacial lake, but more than 100 feet lower than what is now fast becoming the modern Lake Vyrnwy, appears to be conclusive. The waters of the ancient rock basin, scored out by glacial action, were doubtless held up by the very bar of rock on which the present dam has been erected. Higher up the valley, as well as lower down, the rock is farther from the surface than here; and, before the alluvium covered it, water must have submerged the deepest parts and found its outlet over the rocky bar.

The excavation for the foundations of this dam has been made fifty or more feet below the ground level into solid rock, all loose portions having been removed, and the surface protected with sacking from the action of sun and frost until covered by masonry, a precaution also adopted in successive layers as the work proceeded. The dam—so far finished in November last as to permit of water being impounded—is carried to a height of 144 feet above the lowest part of the rock, the total height to the parapet of the viaduct surmounting it being 163 feet. The length of the dam at its upper surface is 1,144 feet, and of the viaduct 1,173 feet. In connection with the viaduct there is a roadway, nearly 12 miles long, round the lake, which will, when full, be $4\frac{3}{4}$ miles long and have an area of 1,165 acres. The greatest depth of water will be about 84 feet; and the capacity, above the level of the outlet to the aqueduct, twelve thousand million gallons. When the rainfall draining into the lake is supplemented by the waters of two rivers, the Afon Cowny, and the Marchnant, now flowing into the Vyrnwy below the dam, but which will eventually be discharged into the lake by tunnels, the daily supply to the Liverpool Aqueduct will be 40,000,000 gallons, besides the compensation water returned to the rivers Vyrnwy and Severn, required by the Act of Parliament.

The cost of the works will be about £1,830,000, the difference between this sum and the Parliamentary estimate, £1,502,094, being more than accounted for by the substitution of a masonry for an earthen dam, and by the execution of other works not included in the estimates. In addition to this, the Corporation has purchased a large estate including nearly all the drainage area, and has expended money in other ways, which will bring the total cost of the first instalment of 13,000,000 gallons of water to nearly £2,000,000. The Act was obtained in 1880; and in all probability the works will be completed in 1890. The masonry of the dam, consisting of clay slate of the lower Silurian series, quarried in the neighbourhood, stands a crushing stress of 800 tons per square inch, weighs 2·06 tons per cubic yard, and has a specific gravity of 2·72. The stones, dressed, washed by hose-pipe, and weighed on the spot, were conveyed along a tramway of 3 feet gauge to the foot of the dam, and lifted by cranes to the surface as the work progressed.

The most minute precautions as to the surface of the rock and superimposed masonry, in addition to those mentioned above, have been taken throughout

to ensure the solidity and tightness of the dam. There are no regular courses, but, while every stone was set on a level bed, each breaks joint with its neighbour, and a stone was selected by the measurer to fill each space left in building. The base of each stone was worked to a flat surface, and, having been let down by the crane into a thick bed of cement-mortar, was hammered down by heavy wooden beetles, and the cement-mortar in the side joints was rammed by special tools, so as to consolidate it thoroughly. The proportion of worked stones to masonry is from 66 to 62 per cent. At the water face of the work the mortar was prevented from filling the joint within 6 inches of the face, by a specially arranged mould, afterwards withdrawn. The space so left was then plugged with strong cement-mortar, which appeared to be almost dry, and which was worked in and rammed with iron tools till the surface appeared damp.

The gravel and sand were thoroughly washed, mixed with artificial sand produced by crushing rock, incorporated dry with the cement, and afterwards mixed with water in special machines, to form the various descriptions of concrete, the coarse varying from 1 part of cement to 5 of gravel at base of the dam to 1 : 8 at the top, while the fine varied from 1 : 2 to 1 : $3\frac{1}{2}$ sand, respectively. The Portland cement was "air-slaked" for 7 to 14 days, according to the weather, by exposing it on tipping shelves in very thin layers before being used; and it is to this practice that is attributed the absence of "hair cracks" in the structure. The cement briquettes, after setting six days in water and two in air, stood a test of 700 lbs. per square inch on an average, and 1,000 lbs. per square inch after several months. The crushing stress of test blocks of cement concrete has varied from 150 to 200 tons per square foot; and blocks cut out of the dam, after having been laid a year, sustained a load of 300 tons per square foot. Mr. Deacon, who projected the work in 1877, having prepared the general plans, became joint engineer with Mr. Hawksley in 1879. In 1885 Mr. Hawksley retired; and the work has since been carried out by Mr. Deacon.

Correspondence.

INDIAN AGRICULTURE.

Mr. Robert Wallace asserted, in the discussion that followed the reading of his paper, in March last, on Indian agriculture, that the cattle of India have black skins, and that not one per cent. had skins of other colours; as the subject possesses some practical importance in connection with the improvement of Indian cattle, I venture to hope that space may be found for the following extract from the *Indian Agriculturist*, of April 6th.

WILLIAM R. ROBERTSON,
Principal, College of Agriculture, Madras,
on furlough.

May 1st, 1889.

Extract from Editorial Notes in the "Indian Agriculturist," April 6th, 1889.

"In continuation of our remarks in a recent issue on Professor Wallace's so-called discoveries as to the colour of the skins of Indian cattle, we think it useful to place the following facts on record, which we have obtained from an indisputable authority, relating as they do to the colour of the skins of cattle in the Southern Presidency. It will be remembered that Mr. Benson considers that Mr. Wallace's theory is the baseless fabric of a vision. Another authority in South India, a native gentleman, confirms him in stating, after examining the skins of several hundreds of cattle, that hides of colours that are not black are in the majority, whilst the result of the examination of over 1,000 head in one district of the Southern Presidency has been to show that 62 per cent. of these had skins which were not black, these animals being of many different breeds. In Bombay also, we are informed that results somewhat similarly confirming our views of Mr. Wallace's hasty generalisation have been obtained."

General Notes.

ITALIAN TRAMWAYS IN 1888.—The total length of Italian steam tramways in 1888 amounted to 2,262 kilometres (kilometre = ·621 of a mile), distributed as follows:—Tramways established on national roads, 140 kilometres; tramways established on provincial roads, 1,572 kilometres; on commercial roads, 269; and tramways on roads which are not public, 281 kilometres; making a total of 2,262. Of all the districts, Lombardy is the best represented, having a length of 905 kilometres, or nearly 40·5 per cent. of the total extent. The first steam tramway worked, was that from Cunéo to Borgo-San-Dalmazzo, which was opened on the 24th May, 1878. The lines now being worked number 110, and belong to 44 companies. The speed at which the tram-cars travel varies from 15 and 25 kilometres an hour, and on the majority of the lines the speed is about 18 kilometres.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings at Eight o'clock:—

MAY 22.—"The Use of Spirit as an Agent in Prime Movers." By A. F. YARROW. Sir EDWARD J. REED, K.C.B., F.R.S., will preside.

MAY 29.—"The Science of Ventilation as applied to the Interior of Buildings." By D. G. HOEY. Sir DOUGLAS GALTON, K.C.B., F.R.S., will preside.

Foreign and Colonial Section.

Tuesday evenings, at Eight o'clock:—

MAY 28.—"The Westinghouse System of Central Station Electric Lighting in the United States of America." By JAMES E. HUMBIRD. W. H. PREECE, F.R.S., will preside.

Indian Section.

Friday evenings, at Eight o'clock:—

MAY 31. — "Indian Wheats." By JOHN McDOUGALL. Sir WILLIAM W. HUNTER, K.C.S.I., C.I.E., will preside.

Cantor Lectures.

The following course of Cantor Lectures will be delivered on Monday evenings at Eight o'clock:—

H. GRAHAM HARRIS, M.Inst.C.E., "Heat Engines other than Steam." Four Lectures.

LECTURE III. — MAY 20TH. — Gas-engines—History—Lenoir—Hugon—Electrical firing—Direct flame firing—Otto and Langen—Bischoff—Compression—Crossley—Crossley's igniter—Clerk—Atkinson—Griffin—Other engines—Turning effort on crank shaft—Possible efficiency of the gas-engine—Actual efficiency—Losses—Practical difficulties—Modes of overcoming these—Suggestions for improvement—Crossley's compound gas-engine—Turning effort on crank shaft—Application of the regenerator—Siemens's regenerative gas-engine—Dowson gas—Water gas.

LECTURE IV.—MAY 27.— Petroleum-engines—Brayton and others—Other orms of heat-engines—Gunpowder pile-dri7er — Guncotton-engine—Honigman's caustic soda engine—Mixed air and steam-engine— Ether and steam— DuTrembley— Recent American experiments — Yarrow — "Arktos" — Electrical heat-engines — Thermopile — Edison — General conclusions.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, MAY 20...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. H. Graham Harris, "Heat Engines other than Steam." (Lecture III.)

British Architects, 9, Conduit-street, W., 8 p.m.

Asiatic, 22, Albemarle-street, W., 4 p.m. Annual Meeting.

East India Association, Westminster Town-hall, 2½ p.m. Discussion on Mr. C. W. Whish's paper on "The Indian National Congress and the Indian Patriotic Association."

Victoria Institute, 7, Adelphi-terrace, W.C., 8 p.m

TUESDAY, MAY 21...Royal Institution, Albemarle-street, W., 3 p.m. Prof. E. Ray Lankester, "Some Recent Biological Discoveries." (Lecture I.)

Civil Engineers, 25, Great George-street, S.W., 8 p.m. 1. Discussion on Mr. W. H. Greenwood's paper, "The Treatment of Steel by Hydraulic Pressure, and the Plant employed for the purpose." 2. Mr. Ernest E. Sawyer, "West of India Portuguese Railway and Harbour Works."

Statistical, School of Mines, Jermyn-street, S.W., 7¾ p.m.

Pathological, 53, Berners-street, Oxford-street, W., 8½ p.m.

Zoological, 11, Hanover-square, W., 8½ p.m.

WEDNESDAY, MAY 22...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. A. F. Yarrow, "The Use of Spirit as an Agent in Prime Movers."

Geological, Burlington-house, W., 8 p.m. 1. Major-Gen. C. A. McMahon, "Notes on the Hornblende Schists and Banded Crystalline Rocks of the Lizard." 2. Mr. Thomas Roberts, "The Upper Jurassic Clays of Lincolnshire." 3. Mr. James R. Kilroe, "Origin of Movements in the Earth's Crust."

United Service Institute, Whitehall-yard, S.W., 3 p.m. Deputy Surg.-Gen. W. G. Don, "Recruits and Recruiting."

Patent Agents, 19, Southampton-buildings, W.C., 7 p.m. 1. Discussion on Mr. Ellis's paper. 2. Mr. W. Lloyd Wise, "Recent Practice in cases of Opposition." 3. Mr. A. M. Clark, "The Contemplated Reforms in the Patent law of France."

Royal Society of Literature, 21, Delahay-street, S.W., 1 p.m.

Cymmrodorion, 27, Chancery-lane, W.C., 8 p.m. Rev. Professor Sayce, "The Legend of King Bladud."

Inventors' Institute, 27, Chancery-lane, W.C., 8 p.m. Mr. W. Boyle, "Horse-shoes, and other means of preventing Slipping on Asphalte and Wood Pavements."

THURSDAY, MAY 23...Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Prof. Dewar, "Chemical Affinity." (Lecture II.)

Electrical Engineers, 25, Great George-street, S.W., 8 p.m. Mr. William Mordey, "Alternate Current Working."

FRIDAY, MAY 24...Linnean, Burlington-house, W., 8 p.m. Annual Meeting.

Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting, 9 p.m. Rev. S. J. Perry, "The Surface during the last Ten Years."

Quekett Microscopical Club, University College, W.C., 8 p.m.

Clinical, 53, Berners-street, W., 8½ p.m.

SATURDAY, MAY 25...Physical, Science Schools, South Kensington, S.W., 3 p.m. 1. Rev. T. Pelham Dale, "A Relation existing between the Density and Refraction of the Gaseous Elements, and some of their Compounds." 2. Mr. George Fuller, "A Waterspray Influence Machine." 3. Prof. S. P. Thompson, Notes on Polarised Light:—(*a*) "The Transition Tints of various orders;" (*b*) "Lecture Illustrations of the Rotation of the Plane of Polarisation;" (*c*) "The Rotation of Circularly Polarised and Non-polarised Light." 4. Dr. Edmund Naumann, "Terrestrial Magnetism as modified by the Structure of the Earth's Crust." 5. Dr. J. H. Gladstone and Mr. W. Hibbert, "The Molecular Weight of Caoutchouc."

Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Mr. J. Bennett, "The Origin and Development of Opera in England." (Lecture IV.)

Journal of the Society of Arts.

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FRIDAY, MAY 24, 1889.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

EXAMINATIONS, 1889.

The list of successful candidates in the Examinations for the present year has been printed, and is forwarded to the Institutions in Union with the present number of the *Journal*. Copies will also be sent to the various committees for the successful candidates.

CANTOR LECTURES.

On Monday evening, May 20th, Mr. H. GRAHAM HARRIS, M.Inst.C.E., delivered the third lecture of his course on "Heat Engines other than Steam," in which he dealt with the subject of gas-engines.

The lectures will be published in the *Journal* during the summer recess.

Proceedings of the Society.

TWENTY-SECOND ORDINARY MEETING.

Wednesday, May 22nd, 1889; Admiral the Right Hon. SIR JOHN C. DALRYMPLE HAY, Bart., K.C.B., D.C.L., F.R.S., in the chair.

The following candidates were proposed for election as members of the Society:—

Bettger, Alfred, 21, Victoria-road, Kilburn, N.W.
Hart, John William, Thatched House Club, St. James's-street, S.W.
Hartridge, William, 6, Drapers'-gardens, E.C.
Metcalfe, Sir Charles Herbert Theophilus, Bart., 2, Victoria-mansions, S.W.
Milbank, Frederick Henry, 13, Upper Hamilton-terrace, N.W.
Pritchett, Robert Taylor, Esq. 4, Norland-terrace, Holland-park. W.
White, Harry Dow, 15, New Broad-street, E.C.

The following candidates were balloted for and duly elected members of the Society:—

Burmester, J. W. Stanley, 36, Great James-street, Bedford-row, W.C.
Chapman, Albert Barnes, 2, Delrow-terrace, Buxton. Derbyshire.
Gardner, Samuel, B.A., Spring-hill, Upper Clapton, E.
Griffin, Samuel, Kingston Ironworks, Bath.
Higgs, William, Gas Works, Basingstoke.
Kenyon, Lord, Gredington, Whitchurch, Salop.
Smythies, Frederic Kynnersley, 52, Ravensdale-road, Stamford-hill, N.
Spencer, Richard, Holker-street, Barrow-in-Furness.
Tredegar, Lord, Tredegar-park, Newport, Mon.
Viney, Rev. Josiah, Alleyne-house, Caterham-valley, Surrey.

The paper read was—

THE USE OF SPIRIT AS AN AGENT IN PRIME MOVERS.

By A. F. Yarrow.

The paper which I have the honour to submit to you this evening has been prepared at the request of the Council of your Society, and deals with the use of spirit as an agent in prime movers. It is not intended to treat of the adoption of spirit or liquid hydrocarbons, such as petroleum, when used as a substitute for coal as fuel, which is an entirely distinct subject, but with the use of volatile liquids in lieu of water, to produce power, when converted by heat from the liquid to the vapour state, in the same way that power is obtained from the conversion of water into steam.

I may mention that in the year 1856 this subject attracted much attention in France, and as a matter of fact, several large steamers were built and ran between Marseilles and Algiers, in which ether was evaporated in combination with steam for working the propelling machinery. I am indebted for the information concerning these vessels to Mr. F. K. Barnes, late of the Admiralty, who visited and made a passage in one of them in order to report to the British authorities concerning

their performance. The engines were on the Du Tremblay system; the steam, after having performed work in one cylinder, instead of going at once to the condenser, was used to evaporate ether in a tubular evaporator, by which means a portion of the remaining heat in the steam was absorbed instead of being wasted; the ether vapour so produced was used in another cylinder, the additional power thus obtained being a clear gain. These steamers ran, making regular voyages, for some years, but were ultimately abandoned. To more clearly explain the main features of this system I would ask you to refer to the diagram No. 1 (on the wall) which gives an outline of the arrangement. A is a steam boiler; B is an ordinary inverted direct-acting steam-engine; C is the evaporator containing a number of tubes through which the exhaust steam from B passed; the body of this evaporator contained ether, which absorbed heat from the exhaust steam, and was converted into vapour which passed on and worked the ether engine, D; E is the surface condenser in which the ether was condensed.

The gain obtained is clearly due to the ether taking a a portion of the heat of the exhaust steam and turning it to useful account, which would otherwise be wasted in raising the temperature of the condensing water. The ether used evaporates at about 104° Fahr., it will therefore be seen to what a low temperature the steam or water can be brought down, and still be useful in evaporating the ether.

The system was no doubt economical as regards fuel, but the ether was so difficult to keep, that a renewal of about 1 gallon per hour was required to make good the leakages. There was also serious risk of explosion on account of these leakages, because the ether, when free, rapidly vaporises, and when in this state is explosive if mixed with the atmosphere. The difficulties which at that time had to be dealt with are, however, now greatly reduced. Ether being the spirit used, was far more costly than other volatile liquids which are available now, and, consequently, any leakage then represented an important item in the working expenses. Also, at that period, means for obtaining good workmanship were not available to the engineer as they are at present, and I may mention that accuracy of workmanship, and soundness of materials are essential points in dealing with the vapour of these volatile liquids, as it penetrates joints and castings which no steam would do; in fact, an amount of care is necessary beyond what is needed in the best steam-engine practice, and sufficiently good work was not available thirty-two years ago.

My attention was first drawn to the subject by the success of some small boats lately built in the United States, propelled by spirit vapour, and we took the matter up with a view to investigate it, and see whether the results would justify our going fully into the matter with a view to its further development. I am glad to say that these preliminary investigations look promising; the results obtained I propose to lay before you this evening.

The apparatus with which our experiments were tried I shall now proceed to explain, and trust to be able to make the whole arrangement perfectly clear to the meeting. It will be seen that we have a small steam-engine of ordinary construction, which actuates a shaft and fly-wheel in the usual way. There is a brake attached to the shaft, with a spring balance and index; also a revolution counter, so that we are enabled to obtain the actual power developed. There is also fitted to this little engine an ordinary indicator, from which to obtain diagrams.

The steam boiler has no special feature about it; it has simply a combustion chamber and a straight flue through to the funnel. There is no attempt at economy of fuel, because there was no object in so designing it; all we wished to obtain being the comparative results on a common basis. The heat is obtained by means of ordinary gas, burnt in a large Bunsen burner made by Messrs. Fletcher and Co., of Warrington. We selected gas as the means of heating because the exact quantity could be accurately regulated and recorded, and with this view there is attached to the inlet pipe a gas-meter. From the boiler to the engine is led a steam-pipe. The exhaust from the cylinder passes out and terminates in a coil of pipe immersed in a tank of running water for the purpose of condensing the steam; this tank is on the right-hand side of the apparatus. From there the condensed steam runs into a hot-well, and passes on to the feed-pump on the engine, and is forced back into the boiler, so that an entire circuit is made. This completes the arrangement for working the engine by steam.

Now, for the corresponding system, when spirit vapour is used, inside the upper part of the boiler is a copper coil, the inlet to which is at the side, and the outlet at the top, whence it passes to the engine. The exhaust pipe

from the cylinder is led in this case into the tank on the left-hand side of the apparatus, where the vapour is condensed and passes on to the hot-well, thence to the pump, and is forced back into the coil inside the boiler, thus making this circuit complete.

We adopted two sets of pipes, condensing coils, &c., so as to avoid, as far as practicable, any mixture of water and spirit, which would tend to vitiate the experiments. To make the system of pipes clear, I have had those in connection with steam or water painted dark blue, and those in connection with the spirit and spirit vapour painted red.

It will be evident that when we raise steam in the boiler we have the means of working our little engine either by steam or by spirit vapour. When steam is used, the stop valve on the pipe leading direct from the steam space in the boiler is opened, and the gear on the right-hand side of the apparatus brought into operation. In this case the internal copper coil in the boiler plays no part. On the other hand, when the spirit vapour is used, the stop valve on the end of the internal coil is opened, and the gear on the left-hand side of the apparatus is set to work. How to start the apparatus when steam is used is self-evident. To start it when spirit is adopted it is necessary to run some spirit into the hot-well and turn the engine a few times by hand, so as to force a small quantity of spirit into the coil in the boiler. The heat from the gas flame is first taken up by the water in the boiler, and is then passed on to the copper coil and evaporates the spirit; the water only acting as a convenient means of transmitting the heat from the flame to the spirit. By these means we are enabled to try steam and spirit vapour under precisely similar circumstances with regard to boiler efficiency. Had we adopted for the spirit another boiler, instead of a coil inside the same boiler, some question might arise as to the comparative efficiency of the two boilers, a doubt which is thus obviated. It will be seen that the boiler is fitted with a pressure gauge for steam, a pressure gauge for vapour, a thermometer, and the necessary appendages, so as to get a complete record of all that was taking place.

Our experiments consisted of several continuous trials, each of three hours duration, alternately with steam and with spirit vapour. The wall diagrams 2 and 3 illustrate the results representing average examples; and in order to condense their size I have taken the record of the middle, or second hour of the three hours' trial. Each vertical line represents an interval of time of five minutes, during which period five observations were made; the mean of these five being the spot through which the lines pass. It will be seen that the diagrams show the variations of pressure, revolutions, gas consumption, and stress on brake respectively. The upshot of these experiments is seen in the summary, which points to the fact that although the amount of gas consumed during the three hours was practically the same, being at the rate of 82 and 83 cubic feet, the power obtained, as tested on the brakes was, in the case of spirit, nearly twice that recorded in the case of water, the powers being as 4722 to 2524.

SUMMARY.

Expansion agent used	Steam ..	Spirit
Duration of trial..............	3 hours ..	3 hours
Cubic feet of gas burnt per hour including the amount required to raise pressure at end of trial to what it was at the commencement	82·20 ..	83·48
Mean pressure of spirit in coil ..	— ..	55·80
Ditto steam in boiler..	37·99 ..	30·07
Mean revolutions per minute ..	312·6 ..	552·2
Tension on brake	1·154 lb. ..	1·222 lb.
Foot-pounds per minute obtained on brake	2,524 ..	4,722

At equal intervals during these trials diagrams were taken with an ordinary indicator, and I show on the walls six of each, which form fair average specimens. The working out of these diagrams gives a power, in the case of spirit, of 11,975 foot-pounds per minute, and, in the case of water, of 5,199 foot-pounds per minute, which more than confirms the results obtained by the brake.

It is familiar to us all that spirit evaporates much more readily than water, and the wall diagram 4 illustrates the comparative heat absorbed in evaporating equal quantities of water and spirit at atmospheric pressure. The horizontal distance on the diagram represents time, and the height represents quantity, from which it will be seen that it takes nearly nine times as long to evaporate equal quantities of water as it does spirit; or, in other words, a given amount of heat will evaporate nine times as much spirit as it will water. Water being a uniform body the line is straight; the spirit line is curved because the spirit is not uniform, being really a mixture of various hydrocarbons, the more volatile passing off first.

Touching the class of spirit which we used

for our experiments, I would mention that it is a hydrocarbon distilled from petroleum, having a specific gravity of about ·680, water being 1·. The reason this spirit has been adopted is because it is low in price and can be easily procured; and also, being obtained from petroleum, it is of an oily nature. A spirit which is not oily in its character would be deficient in lubricating power, and therefore not so suitable for working the machinery.

As I thought it would be of interest to show the position occupied by the spirit adopted by us throughout in these trials, with reference to other products of petroleum, I here give the names and respective specific gravities of a few.

Gasoline	·650
Launch spirit	·680
Benzoline	·700
Benzine	·725
Refined petroleum of commerce	·800

The wall diagram 4 shows the relative quantity of spirit and water evaporated by the same amount of heat, but it will not show the comparative advantages of using the one or the other, except taken in conjunction with the volume of vapour or steam respectively obtained from the same quantity of spirit or water, because in the production of power it is the difference between the volume in its liquid and vapour state at a common pressure that determines the results obtained.

With a view to experimentally ascertain the density of spirit vapour as compared with steam, Mr. Boverton Redwood kindly undertook this investigation, the result of which is that petroleum spirit gives about one-fifth the volume of vapour that water yields. Taking this in conjuction with the result shown on the wall diagram 4, it would appear that a given amount of heat will produce one and four-fifths the bulk of spirit vapour at atmospheric vapour that it would if used to convert water into steam. This result, therefore, tends, as far as it goes, to further confirm the gain in favour of spirit.

With a view to illustrate the difference of pressure between steam and the spirit we use at common temperatures, I may refer to the wall diagram No. 6. The upper line represents the pressure of spirit vapour, and the lower line the pressure of steam. It will be seen, for example, that 240° temperature corresponds to steam at a pressure of 10 lbs., and spirit vapour at a pressure of 65 lbs. It also shows that water at boiling point, or steam, 212°, can convert spirit into vapour at 45 lbs.

Touching the evaporation of spirit to produce power in actual practice, at present the only application which has been successfully developed is for the propulsion of launches. It is termed the "Zephyr" system. I may mention that of this type of launch we have already built a large number, and they are finding great favour. For small sizes certainly there would seem to be no question that, where the spirit is obtainable, this system is destined to take the place of steam, not so much on account of the probable increased efficiency, as the general convenience of the arrangement.

The diagram on the wall represents a launch propelled on this plan. It is 36 ft. long by 6 ft. beam, and is built of steel. Its total weight, including machinery, is only one ton; and, I need scarcely say, that had it been propelled by steam the weight would have been considerably greater.

The propelling machinery, being light, can be placed at the stern; it consists of an engine which is so enclosed as to avoid leakage of vapour. The generator is placed aft of the engine, and consists of a copper coil enclosed within a double sheet-iron casing, the intermediate space being filled with asbestos or other non-conducting material. Below the coil is an iron pipe, bent into the form of a ring, perforated with holes and arranged as an ordinary ring gas-burner.

An eight-horse power evaporator is shown on the table, from which it will be seen how small an apparatus it is.

In the bow is an air-tight copper tank, of a capacity of 40 gallons, for containing the spirit; this serves in a measure to balance the engine at the stern. The tank is placed in communication with the feed pump by means of a pipe passing outside the boat close to the keel. The feed pump delivers into the bottom of the vapour generator, and the exhaust from the engine passes into the two condensing pipes, placed longitudinally, one on each side of the keel. The vapour is condensed in these pipes, and is forced back into the tank by the action of the engine.

There is a spirit hand pump, having its suction connected with the tank, and its delivery joining the bottom of the evaporating coil, so that by working it spirit can be drawn from the tank and forced into the coil. Now, in order to start the launch, a little heat is first applied to the evaporating coil, and then a small quantity of spirit pumped into it by hand,

which is immediately converted into vapour, and the pressure begins to rise. By opening a valve a small portion of this vapour is arranged to pass into the ring burner, and is ignited, together with a suitable proportion of air; and from this moment the heating process is self-acting; so long as there is vapour in the evaporator a portion of it will go to heat up the incoming liquid. The engine can now be started, the feed-pump on the engine providing a continuous supply of spirit to the coil; from this moment the action throughout will be automatic, and when once started neither the engine nor the evaporator requires any further attention.

After the vapour has left the engine, it passes through the exhaust pipes under the boat, is condensed and forced into the tank in the bow, to be used over and over again.

A boat of this type will run eight miles an hour easily, and carry fuel for 200 miles.

Owing to the rapidity with which spirit evaporates, as a matter of fact, from the time of lighting up it does not require more than five minutes on an average to start the boat.

It will be seen that the entire central portion of the hull is available for passenger accommodation, and is not hampered by a boiler, as in a steam launch, which usually is a source of considerable inconvenience, and occupies the best part of the space. The small weight of the machinery is also a point of importance, as it tends to reduce the draught. The whole arrangement is so exceedingly simple that a fairly intelligent stranger can learn how to work it in an hour's run.

Although the spirit indicated in the summary on page 600, having a specific gravity of ·680, is what we use for our launches, grades lighter and heavier may be adopted within certain limits, gasoline on the one hand, and benzoline on the other, the lighter giving a better and the heavier an inferior result.

I will not venture to assign any reason for the apparent gain in the use of spirit over water but I would point out that, in a condensing engine, the two great losses of heat are due, firstly, to the waste gases which pass up the funnel, and simply go to raise the temperature of the surrounding air, and, secondly, to the loss arising through raising the temperature of the condensing water, which goes to warm the sea.

As regards the first loss, it is self-evident that, owing to the low temperature at which the spirit evaporates, the products of combustion are available to produce evaporation down to a much lower temperature than in the case of water. As an illustration of the low temperature at which the waste gases pass away in the "Zephyr" launches, when going at full speed it is quite possible to hold one's hand immediately over the funnel.

I have now explained the results of the experiments we have made to test the value of spirit as an evaporating agent to produce power; I have also described one successful practical application of it; and I submit if these results are further confirmed by experience, there is reasonable ground for believing that this system in some form is capable of further and possibly extensive development.

DISCUSSION.

The SECRETARY read the following letter from Sir Edward Reed, K.C.B., F.R.S.:—

Broadway-chambers, Westminster,
London, S.W., May 22nd, 1889.

DEAR SIR,—I extremely regret that the death of a near relative prevents me from carrying out my engagement at your Society this evening, where I had hoped to preside at the reading of a paper by Mr. Yarrow, upon the novel system of obtaining power in small steamers. Had I been able to attend, I should have taken leave to state to the meeting that in my opinion this new means of obtaining power is one of the most interesting and promising before the scientific world at the present time. I should not be surprised if, in further development, it should come to play a very important part in the future.

Be so kind as to convey my apologies for my absence both to the Society and to the meeting, and believe me, dear sir,

Yours very truly,
E. J. REED.

The Secretary of the Society of Arts.

Mr. BOVERTON REDWOOD said he had been interested in petroleum for many years, and he was therefore very glad to undertake, at Mr. Yarrow's request, an investigation into the results he had obtained, especially with a view of ascertaining the relative vapour densities of the hydrocarbons he employed, and steam. The results of the experiments which he made, in conjunction with Mr. Bernard Dyer, indicated that the petroleum spirit employed yielded practically one-fifth the volume of vapour yielded by water under similar conditions of boiler pressure; and it was therefore obvious that the results Mr. Yarrow obtained were largely due to the difference in the specific and latent heat of water and petroleum spirit. In the latter case the figure was remarkably low, so that the number of heat units used up in raising it from atmospheric temperature to that

corresponding with the boiler pressure at the time was very small in proportion to the number used in raising water to the corresponding point. Similarly, the amount of heat rendered latent in the conversion of a given weight of spirit into vapour, under a given pressure, was far smaller than that rendered latent in converting an equal weight of water into vapour under the same pressure. He felt bound to state, however, that his direct experiments with regard to the relative specific heats of petroleum spirit and water did not wholly account for the results obtained by Mr. Yarrow in practice. He did not pretend to be an engineer, but having carefully examined the apparatus with which Mr. Yarrow had made his comparative trials, he had not been able to suggest any flaw in his process of reasoning, and having travelled in several launches made on this system, he had been much impressed by the advantages it presented, entirely apart from the question of economy. The rapidity with which the engine could be started was a point of considerable importance; there was an entire absence of stoking, and of the general inconvenience attaching to the use of solid fuel, also of smoke, advantages which those who used steam launches would fully appreciate. Further, the large space left free was another great point, and the carrying capacity for fuel would be probably of primary importance with regard to the use of this system for belligerent purposes, especially torpedo boats, where it was of vital importance to be able to carry the maximum of fuel in the minimum of space. If Mr. Yarrow had erred at all in bringing forward the claims of this system of propulsion, it was on the side of modesty; he had dealt with the matter in a judicial spirit, not as an advocate.

Mr. J. E. DOWSON asked if Mr. Yarrow could say anything as to the relative advantages of using a given weight of spirit n the way described, and by burning it directly in a petroleum engine. He forgot the exact figures, but he knew the power developed in a petroleum engine was considerable for a given weight of oil, and as a matter of practical efficiency it might be useful to have the comparison he suggested. In the one case the whole of the petroleum was used directly, in this only a small portion was used as fuel by converting the larger portion into vapour.

Professor LAMBERT remarked that when Mr. Yarrow first brought this matter forward at the Institute of Naval Architects, certain hasty critics condemned it straight off as being unscientific and impracticable, and said that Mr. Yarrow professed to have discovered a new motive power which was to revolutionise marine propulsion. But Mr. Yarrow never professed anything of the kind; he simply claimed that for a certain type of engine, such as was used in small launches, there was a considerable advantage in using spirit as an evaporating agent, as compared with steam, in the matter of efficiency; and a most decided gain in convenience. A year's experience of the boats Mr. Yarrow had constructed had dissipated any doubts which were at first entertained, for he believed one ran continuously at Glasgow, during the Exhibition, for three months, without the slightest hitch. He suggested a scientific explanation of the efficiency of these engines different from that which Mr. Redwood had put forward. A simple thermo-dynamic law showed that that efficiency in a perfect engine depended on the range of temperature between which the expansive agent worked, this efficiency being expressed by the fraction $\frac{T_1 - T_2}{T_1}$, T_1 being the absolute temperature of the source of heat, and T_2 that of the condenser. No doubt the small latent heat of spirit caused it to take the vaporous form with small expenditure of heat, but Mr. Yarrow had guarded himself against putting that forward as the interpretation. It would not do to say that, because you got a certain quantity of liquid into vapour with a small expenditure of heat as compared with water, therefore it was economical. The object was to turn heat into work, and at first sight it might appear that the more heat you could put into a vapour, the more work you could get out of it; but that would not be necessarily true either. Given a mass of vapour containing a certain quantity of heat, the more you could cool that vapour by its own expansion the more of its heat you could turn into work. If you could cause it, by expanding as vapour, to cool itself down to absolute zero of temperature, you could turn all its heat into work. This is impossible, of course, as it would condense into a liquid long before this zero was reached. Taking the figures obtained from the model when worked by steam and vapour respectively, we see that we might, under similar conditions, have steam at 25 lbs. pressure and temperature 265° F., or naphtha vapour at 50 lbs. pressure and temperature 220°. In the case of steam, the range of temperature was from 265° to 212°, or a range of 53°, whereas in the case of naphtha the range was from 220° to about 130°, or a range of 90°. Using the fraction above given, the denominator in each case being practically the same, the efficiency would be nearly in the ratio of 53 to 90, naphtha having the advantage, and this would about account for the results not only as shown in the model engine, but also in the Zephyr launches. Shortly, then, the explanation of the increased efficiency lay in the larger range of temperature through which the spirit vapour worked. But, after all, the gain of efficiency did not seem to him so important as that of convenience, and the marvellous ease with which these boats were manipulated. He was a poor engineer and a worse sailor, but he could trust himself to undertake a cruise in one of these boats from Poplar to London-bridge and back alone, and he felt sure that any intelligent person could learn how

to manage the whole thing in half an hour. On stepping on board you had simply to give a few strokes to a little hand-pump, to draw the air charged with vapour from the surface of the tank into the burner, then light it, and work another pump for a few seconds, to put a little spirit into the coil, which was almost instantly evaporated, and then the engine began to work. In three or four minutes you were under weigh, and afterwards everything went on automatically. He had heard the objection that there was a smell sometimes, and so there was with a paraffin lamp if it were turned too high; all you had to do was to turn it down. The owner could go on board, and manage the whole thing almost without soiling his hands, and ladies on board need have no fear of injuring their dresses. The whole boat only weighed about a ton, and three-fourths was accounted for by the boat itself, the tank and little engines being stowed away in the extreme bow and stern, and together weighing only about five cwt. Mr. Yarrow was extremely modest, but he could not help thinking that there was an immense future before this system of propulsion, which even he had hardly yet realised. It must not be forgotten that the advantage possessed by spirit in these engines was due to condensation taking place under atmospheric pressure, and that if you used engines of a higher type, condensing under an air pump, that advantage would disappear, and, therefore, the application of this agent was, he thought, limited to engines of a simple class. Mr. Yarrow, he thought, might be congratulated on the great success he had achieved with these little motors. He knew that many orders had already been placed for them, and he felt sure that they were destined to be largely adopted.

Mr. DUNELL feared he was one of the hasty critics referred to by the last speaker, who did not at first believe in the spirit launches, but having seen them at work, he was soon converted. He made a trip up the river in one from Poplar to Henley, at the time of the regatta, but there really was nothing to be said about it, for he had only to start the engine, and then sit down and watch it. Afterwards Mr. Yarrow was kind enough to lend him one for a fortnight, in which he went down to Cowes, and there the same experience was repeated. Mr. Yarrow was rather outside the mark in putting five minutes as the time required to start the engine, for he had noted it on more than one occasion, and fouud it took about two minutes. The extreme cleanliness of the arrangement was another striking feature. He learned how to manage it in ten minutes, and anyone could do the same who knew how to turn a valve. He could not add anything on the thermo-dynamical question to what Professor Lambert had said, but he could confirm what Mr. Yarrow stated, that in this engine, when running at full power, you could hold your hand over the funnel, so that there was not that immense waste of heat which usually took place, and that he thought accounted for a good deal.

Mr. ARTHUR RIGG said everyone who had to do with steam launches would recognise the enormous advantage obtained by getting rid of the boiler. For small powers Mr. Yarrow had succeeded very well indeed, but it must be recollected that steam at 37 lbs. pressure was not economical, and if a comparison were made between steam-engines working at, say, 120 lbs. and the petroleum engine, the advantage might not be so great. Still, he thought there would be an economy. One of the most interesting points referred to was the extreme volatility of spirit vapour, which escaped through all sorts of places where steam would never find its way; and though the machinery might be made as perfect as possible, if a leak did occur when you were 200 miles away difficulties might arise. He had placed on the table a model of an engine with four cylinders entirely closed up, and which ran very quietly, so that whatever vapour might escape from the piston or working parts it could not get away; and something of that kind would tend to remove the evil which everyone on the Thames complained, the smell behind these spirit launches, not in them, and which no doubt arose from imperfect combustion. Here the flame played on comparatively cool copper tubes, and he would suggest that a small clay furnace might be introduced, which would produce more perfect combustion, and this would remove the only evil attendant on these launches.

Admiral BOYS thought this invention would be of especial use in torpedo warfare. Every naval man was aware that the great difficulty in the day time was the smoke, and in the night time the steam, which always escaped to some extent when a boat had to stop, and which was made visible immediately by the electric light, and betrayed your position to the enemy. As there was no steam and no smoke with these engines, he thought they would develop great changes in naval warfare. He feared the pipes along the keel were in rather a dangerous position, as boats were always liable to ground, and they might then be injured.

Mr. G. W. GARRETT could not agree with Professor Lambert that petroleum would not be suitable for large engines. On a matter of theory he would bow to his authority, but, in a sense, all things were equally good in theory for producing motive power, and it was because they could not act altogether by theory that one thing was better than another. If you could take out all the heat put into the water, the result would be as good as in the case of petroleum, but there lay the difference. The fact was, you could make a machine which would take out the power from spirit vapour more completely than one you could make for taking out the power from steam. The Du Tremblay results were very remarkable, and if he had known of petroleum, he would probably have succeeded entirely. The difficulties of the engineers arose in matters of

detail, and he, by using ether vapour, which was a solvent of grease, and very difficult to manipulate, found more difficulties than he could overcome; whereas now, having a vapour which was itself a lubricant, many of those difficulties disappeared, and a spirit could be selected just of the right special gravity, to suit either cast steel or cast iron, as might be deemed best. He felt confident that if Mr. Yarrow continued his experiments, before long they would see the same system successfully applied to large engines. As had been said, the object of late had been to use the highest pressures—he believed Mr. Perkins had used 500 lbs.—but there were very great technical difficulties involved, and it would be much simpler to employ petroleum vapour at such a pressure than steam. There might be difficulties from the fact that it was explosive, heavier than air, and so on, but these would no doubt be overcome.

Mr. E. HUMAN said there was one advantage in the use of this spirit which had not been mentioned—that it would not freeze at exceedingly low temperatures. The diagrams showed that the back pressure was rather greater than in the case of steam, which was in part explained by the boiling point of naphtha being so much lower than that of water, and therefore there was a higher pressure, corresponding with the normal condensing temperature. It would be therefore desirable to have the condensing water as cold as possible. In the launches the back pressure on the piston arose from the fact of having to pump into the tank, which was not the same thing as the back pressure shown on the indicator diagrams. The latent heat of evaporation and specific heat of petroleum being so much less than that of water had been referred to as the cause of efficiency, but there was another point also, viz., the latent heat of the expansion of the liquid. As yet there was no evidence how that affected the efficiency, but the curve of spirit vapour on diagram 6 showed it was possible to calculate the latent heat of evaporation, and he had worked it out for a pressure of 56 lbs. in the coil. The result must be received with caution, as he had done it hurriedly; but he found the value of latent heat per cubic foot was 77,800 foot-pounds, whilst the corresponding latent heat of steam at 38 lbs. pressure was 88,740 foot-pounds. This went to show that, as the latent heat and specific heats were less, the factor at the bottom of the expression which gave the efficiency of an engine must necessarily be less. There was also the latent heat of expansion of the liquid to be considered, as in water there was no latent heat of expansion. On a rough estimation of the amount of stuff passing through this experimental apparatus, taking it between tolerably wide limits, there was between twice and four times as much volume of spirit liquid as water, and taking those extremes, he found the efficiency lay between ·094 and ·093. It did not depend so much on the amount of liquid going through as on the other quantities, the latent heat of evaporation being the most important factor. On the same basis of comparison, taking steam at 38 lbs. and spirit at 56 lbs., the efficiency of the steam-engine would be ·05, and the ratio of efficiency of spirit to steam between 1·69 and 1·67, or, roughly, $1\frac{2}{3}$, and that agreed pretty well with what Mr. Yarrow had found. The relation between the pressure and volume had not yet been determined, and all these things had to be found before the thermo-dynamics of the question could be thoroughly worked out. With regard to the expression Professor Lambert had put on the board, while he would bow to his authority on a matter of theory, he could only say that practice did not come up to it. He thought it hardly applied to the case of an engine where there was a change of state in the material used, or it would lead to very extraordinary results. For, instance it seemed to him that according to that expression the efficiency of an engine running steam to the end of the stroke would be the same as one with a cut-off and working expansively, which they knew was not the case, and in certain conditions it would tend to show that a steam-engine had no efficiency at all.

Professor LAMBERT said he had been misunderstood by the last two speakers. He did not, as Mr. Garrett seemed to think, say that petroleum would be useless for large engines; on the contrary, he looked on it as the fuel of the future, and that its application to engines would be unlimited. With regard to the formula he had put on the board, it expressed the maximum efficiency which could be got out of an expansive agent in a perfect engine working in a complete cycle; he never said it represented the actual efficiency of this particular engine. The indicator diagram drawn by the last speaker did not by any means represent the working of a perfect engine, and would not therefore be a test of the formula. The formula was the correct one as expressing the maximum efficiency attainable in a perfect engine, as all who understood the theory would agree. What he maintained was that so long as your condenser was exposed to the air, the extreme limit of the working range of temperature was that of the boiling point of the liquid under atmospheric pressure. If you condensed under an air-pump, you might lower the temperature of condensation of the steam very considerably, and so give it as good a working range as the spirit vapour, and that in this case the advantage shown by the spirit in the lower type of engine would disappear.

Mr. NORMAN asked how much petroleum was used per horse-power per hour in this engine, both in combustion and driving. Again, why was a funnel required; if it was on account of imperfect combustion, he could show how to obtain perfect combustion with petroleum. He had a little furnace, with two small burners, which he had shown at a

meeting of the Aeronautical Society, by which he could drive a two-horse power engine and melt cast iron.

Mr. YARROW, in reply, said about one-third gallon was used per horse-power in combustion; what was vapourised and used to convert into power in the engines was re-condensed, and used over again, and there was practically no loss from this cause. The funnel was to produce a draught. He admitted that it would be better in some respects not to have the pipes outside; but if they were inside, in case any leakage occurred, there might be danger of the spirit finding its way into the boat, so that, on the whole, it was safer to keep them outside, because in this case the spirit would pass away into the surrounding water. Professor Lambert had said he would not mind trusting himself in one of these launches alone. As a matter of fact, in America anyone was allowed to work a spirit launch without a skilled engineer on board, while in the case of a steam launch, it was compulsory to have a competent engineer on board; this fact clearly showed the feeling of the authorities there. With regard to the comparative economy of this method and explosive engines he had no data. He knew such engines were very economical, and if certain practical difficulties in their development could be got over, they would be formidable competitors; but, from what he had seen, he believed there were many difficulties to be removed before they could be considered practically a success, even putting aside any question of economy. He was obliged to Mr. Redwood for his remarks, and was glad to find that his investigations had partly, if not entirely, confirmed his own figures, and he had no doubt that in time some satisfactory arrangement would be come to between theory and observed facts, so that the one would entirely confirm the other.

The CHAIRMAN, in proposing a vote of thanks to Mr. Yarrow, said there were one or two points relating to this invention which struck him as being of great importance in connection with the navy. First, there was the rapidity of starting, for the loss of twenty minutes in getting up steam sometimes might make all the difference between the loss of a ship and the success of an expedition. The lightness of the machinery was another important point, giving, as it did, extra space both for the men themselves as well as arms, ammunition, food, &c., whilst the economy of space for fuel, and of fuel itself, would enable a service to be continued for a much longer period. The absence of smoke and steam, and the accompanying noise had already been alluded to, and this absence was a point of great importance. The only point to which he need refer as requiring further consideration was, whether petroleum, flashing even at a high temperature, would not be liable to be ignited by a shot, which was not the case with solid fuel.

The vote of thanks was carried unanimously.

Miscellaneous.

CULTIVATION OF RED PEPPER IN TURKEY.

The *Journal de la Chambre de Commerce de Constantinople* says that the cultivation of the red pepper plant occupies a very important place among the several branches of cultivation practised in Turkey. This cultivation is chiefly making progress in the cantons of Karadja Abad, in the districts of Vardar Yenidje and of Védine, vilayet of Salonica. Formerly the production of red pepper was unimportant, for it was limited to the requirements of local consumption in the vilayet, but since foreign countries have bought these peppers, cultivation has rapidly extended. The plant itself prefers a sandy and humid soil, where it grows sometimes almost in the water. It is estimated that the plant produces from 120 to 400 okes (oke = 2·84 lbs.) of pepper per deunum (deunum = 40 square paces), according to quality. On an average the expenses do not exceed 300 gold piastres for the cultivation of each deunum, and an oke of this pepper costs from 30 paras up to 5½ piastres, according to quality. The profit realised on the average is from 300 to 350 piastres per deunum. Harvesting only commences when the plants are entirely red. The produce of the first gathering is of superior quality, but that of the last is bad, as the pepper plant reddens imperfectly in the autumn. This year the yield of red pepper has reached in the canton of Yenidje Karadja Abad, the figure of 350,000 okes, and in that of Vediné Karadja Abad, about the same amount. Of this yield 45 per cent. is exported to Europe, 30 per cent. to Bulgaria, Servia, and Austria-Hungary, the remainder being sent to different parts of the Turkish Empire.

General Notes.

THE PRODUCTION OF SEEDS ON THE PACIFIC COAST.—The seed trade appears to be destined to a very great expansion in California, at a not very distant period. In the single county of Santa Clara, not less than 1,200 acres are now devoted to the production of garden seeds. Over 60,000 pounds of lettuce seed, and 120,000 pounds of onion seed have been shipped east from these grounds in a single season. In other counties a quite important business has been developed in the production of clover seed, beans and peas, for the supply of distant markets. Whilst that State may not secure the monopoly of the seed business, because good seeds

are grown in the Atlantic States, the rapid increase of business in California indicates that one at least of the great centres of the seed business is to be in this State. The quality of many small seeds produced here, such as onion and lettuce, will have much to do in bringing the seed interest into greater prominence.

Population of Honduras.—The last census of Honduras, which was taken in 1887, but the results of which have only recently been published, shows a population of 331,917, an increase of 24,628 over the population of 1881. The population was distributed as follows:—128,938 men, 134,107 women-ladinos (mixed or foreign descent), 34,137 men, and 34,735 women-indigenas (Indian descent), making 5,767 more women than men—5,169 more females than males of the ladinos, and 598 more females than males of the indigenas. There are 325,750 Hondurans, 2,000 Salvadorans, 2,060 Guatemaltans, 610 Nicaraguans, 14 Costaricans, 15 Columbians, 29 Mexicans, 185 North Americans, 77 Spaniards, 72 Frenchmen, 1,033 Englishmen, 43 Germans, 4 Russians, 2 Swiss, 13 Italians, 4 Belgians, 2 Danes, 1 Dutchman, 1 Portugese, 1 Brazilian, and 1 Chinaman. The religious denominations are stated as 329,079 Catholics, 777 Protestants, 3 Freethinkers, 17 Rationalists, 399 without religion, 2 Deists, 2 Spiritualists, 1 Buddhist, 1 Lutheran, 1,543 Methodists, 2 Anabaptists, and 91 Baptists.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday evenings at Eight o'clock:—

May 29.—"The Science of Ventilation as applied to the Interior of Buildings." By D. G. Hoey. Sir Douglas Galton, K.C.B., F.R.S., will preside.

Foreign and Colonial Section.

Tuesday evenings, at Eight o'clock:—

May 28.—"The Westinghouse Alternating System of Central Station Electric Lighting in the United States of America." By O. B. Shallenberger. W. H. Preece, F.R.S., will preside.

Indian Section.

Friday evenings, at Eight o'clock:—

May 31.—"Indian Wheats." By John McDougall. Sir William W. Hunter, K.C.S.I., C.I.E., will preside.

Cantor Lectures.

The following course of Cantor Lectures will be delivered on Monday evenings at Eight o'clock:—

H. Graham Harris, M.Inst.C.E., "Heat Engines other than Steam." Four Lectures.

Lecture IV.—May 27.—Petroleum-engines—Brayton and others—Other orms of heat-engines—Gunpowder pile-driver—Guncotton-engine—Honigman's caustic soda engine—Mixed air and steam-engine—Ether and steam—DuTrembley—Recent American experiments—Yarrow—"Arktos"—Electrical heat-engines—Thermopile—Edison—General conclusions.

MEETINGS FOR THE ENSUING WEEK.

Monday, May 27...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. H. Graham Harris, "Heat Engines other than Steam." (Lecture IV.)

Tuesday, May 28...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Foreign and Colonial Section.) Mr. O. B. Shallenberger, "The Westinghouse Alternating System of Central Station Electric Lighting in the United States of America."

Royal Institution, Albemarle-street, W., 3 p.m. Prof. E. Ray Lankester, "Some Recent Biological Discoveries." (Lecture II.)

Medical and Chirurgical, 53, Berners-street, Oxford-street, W., 8½ p.m.

Civil Engineers, 25, Great George-street, S.W., 8 p.m. Annual General Meeting.

Anthropological, 3, Hanover-square, W., 8½ p.m.

Wednesday, May 29...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. D. G. Hoey, "The Science of Ventilation as applied to the Interior of Buildings."

United Service Institute, Whitehall-yard, S.W., 3 p.m. Lieut.-Col. N. L. Walford, "The Tactics of Coast Defence."

Thursday, May 30...Society for the Encouragement of Fine Arts, 8 p.m. *Conversazione* at the Galleries of the Royal Institute of Painters in Water Colours.

Royal Institution, Albemarle-street, W., 3 p.m. Prof. Dewar, "Chemical Affinity." (Lecture III.)

Electrical Engineers, 25, Great George-street, S.W., 8 p.m. Discussion on Mr. Mordey's paper, "Alternate Current Working."

Friday, May 31...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Indian Section.) Mr. John McDougall, "Indian Wheats."

United Service Inst., Whitehall-yard, 3 p.m. Staff-Commander E. W. Creak, "The Marine Compass in Modern Ships of War."

Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting, 9 p.m. Professor Demetri Mendeleef, "An Attempt to Apply to Chemistry One of Newton's Principles."

Browning, University College, W.C., 8 p.m. Paper by the Rev. Garrett Horder.

Saturday, June 1...Royal Institution, Albemarle-street, W., 3 p.m. Prof. W. Knight, "The Classification of the Sciences, Historical and Critical." (Lecture I.)

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FRIDAY, MAY 31, 1889.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CONVERSAZIONE.

The Society's Conversazione is fixed to take place at the South Kensington Museum (by permission of the Lords of the Committee of Council on Education), on Friday, June 28.

Each member will receive a card for himself, which will not be transferable, and a card for a lady. No tickets will be sold.

The cards of invitation will be issued shortly.

CANTOR LECTURES.

Mr. H. Graham Harris, M.Inst.C.E., delivered the fourth and last lecture of his course on "Heat Engines other than Steam," on Monday evening, 27th inst.

On the motion of the Chairman, a cordial vote of thanks to the lecturer was passed.

The lectures will be published in the *Journal* during the summer recess.

Proceedings of the Society.

TWENTY-THIRD ORDINARY MEETING.

Wednesday, May 29th, 1889; Sir Douglas Galton, K.C.B., D.C.L., F.R.S., in the chair.

The following candidates were proposed for election as members of the Society:—

Dexter, Frederick George, Gas Works, Wantage, Berks.

King, Joseph Edmund Sheppard, 38, Tulse-hill, S.W., and 16, Finsbury-circus, E.C.

Mainland, George Edward, Glenthorne, Woodside-lane, North Finchley, N.

Melville, Viscount, Melville Castle, Lasswade, Midlothian.

The following candidates were balloted for and duly elected members of the Society:—

Forrest, Alexander, Gleniffer-villa, Gibson's-road, Heaton-moor, Stockport.

Mildmay, Henry Bingham, 46, Berkeley-square, W.

Myers, Asher Isaac, 2, Finsbury-square, E.C.

Stanton, Major-General Frederick Smith, The Grove, Hillingdon, Uxbridge.

Trench, Gilbert Kennedy, 11, Townley-park-villas, Dulwich-rise, S.E.

The paper read was—

THE SCIENCE OF VENTILATION AS APPLIED TO THE INTERIOR OF BUILDINGS.

By D. G. Hoey.

The subject of this paper is limited to the ventilation, or renewal of the atmosphere, of interiors of buildings, which, in order to its being satisfactorily accomplished, must be effected in such manner as never to cause the impinging of gusts, draughts, or felt currents on the occupants.

Questions relating to the ventilation of stores for produce, of ships' holds, and of other receptacles for inanimate matters, which sustain no injury by the passage over and around them of currents or draughts, are excluded from the scope of the paper. The ventilation of mines, although occupied by miners at work, is also excluded, because there the object in view is quite exceptional, viz., by strong currents set in motion, and carried up shafts, to remove continuously the noxious and explosive gases from the workings, which would otherwise accumulate and cause danger or death. This is, besides, a special department of ventilation, which, conducted by engineers possessing the requisite combination of scientific knowledge and practical skill, stands comparison with the other achievements of these experts in applied mechanics, and does not, therefore, fall under the animadversions which have emanated from the best informed

quarters on the empirical condition of the science generally.

Ancient Systems.

Although several cities in Greece were preserved during a pestilence by Hippocrates, and great cures effected by Varro, by ventilating the houses by opposite apertures—and the ancient Romans were adepts in regulating the temperature of the Laconicum, or sweating stove, of their baths, by placing an opening at the highest point of the ceiling, and regulating the exit of air from this opening by means of valves—the science of ventilation, as applied to inhabited interiors, belongs to the moderns, and was little understood or practised till comparatively recent times.

The terrible devastations of plagues in the ancient and middle ages have been attributed to this total absence of ventilation, and the theory put forth to account for the final total disappearance of plague from London, viz., that it was due to the strong currents of fresh and purifying air occasioned by the gigantic conflagration which intervened at the time of the last great plague, seems to rest on a sound scientific basis.

Origin of Study of the Science in England.

The study of the science in this country, followed by its general application in many directions, originated mainly from efforts to produce effective ventilation in the Houses of Parliament, in which almost every device has been tried from time to time, and the history of their ventilation is synonymous with the history of the science. At Westminster, system has succeeded system in bewildering profusion, and enormous expense has been incurred, whilst the underground passages, with their connecting flues and ramifications, rival in labyrinthine characteristics the catacombs of Rome or of Egypt; yet as these efforts, from first to last, have not produced the satisfactory results to be expected from an expenditure so lavish—the fundamental desideratum of continuously effective yet imperceptible action being still unattained — it need occasion no surprise that the like or greater imperfections should be found elsewhere universally prevalent.

First Record, Middle of 17th Century.

The first record extant of any ventilating process in English houses is so recent as the middle of the 17th century, the means used being similar to the system of Hippocrates already mentioned, viz., by opening a door, or a window, or a hole in the wall or ceiling.

It was on a modification of this plan that Sir Christopher Wren undertook to ventilate the House of Commons in 1660. He made four large square holes, one in each corner of the ceiling, placing over each a truncated pyramid, carried 8 feet up into the room above, with valves in the truncated funnels for opening and closing them. He calculated that "the breath of the people below, and the steam of the candles, would pass upwards from the House through these funnels" into the upper chamber provided for the purpose of receiving them before being carried off through the roof. This is the first instance made known to us of that "foul-air chamber," which has since been used so extensively to no good purpose, which is devoid of all scientific basis, and whose presence, in a more or less marked form, is often a radical defect in outlet ventilating apparatuses where it is least suspected. So far as appears, the sole motive power depended upon for inducing velocity of upward discharge in these short truncated cones was the warmth contained in the products of respiration, combustion, &c., as they rose to the ceiling of the House, and no means seem to have been provided in the outlet apparatus for insulation and prevention of condensation. It is not surprising, therefore, that the action of the pyramidal funnels, when their valves were opened, was found to be frequently the reverse of what was intended, and that the current, instead of moving in an upward direction, and thus carrying off the used and vitiated air, turned downwards, causing showers of cold air—mixed with refrigerated impure air—to descend, to the discomfort and danger of those who sat beneath. No special provision appears to have been made for introducing the fresh air, which was left to be supplied on the system, or absence of system, still widely prevalent, by open or imperfectly-fitting doors, windows, &c.

This and similar expedients, then and subsequently brought into extensive use, were crude and far from satisfactory means for renewing the atmosphere of inhabited interiors, but they were a great improvement on the previous total absence of ventilation; whilst the advantages we possess in advanced knowledge of chemical analysis, quantitative and qualitative, and of the science of atmospheric law and kindred subjects, were not at

the service of the authors of these crude methods, nor of those following them, for a long period. How far we have yet advanced beyond these crudities in the process remains to be considered in the sequel.

Dr. Desaguliers' Plan in 1736.

Another noteworthy attempt at ventilating the House of Commons was that of Dr. Desaguliers in 1736, by means of an exhaust fan intended to draw the vitiated air upwards and outwards, but this plan shared the fate of its predecessors, and was discarded.

Notwithstanding, when I reported on the defective ventilation of the International Exhibition of last year in Glasgow, and the method of removing these defects, I found a similar system of exhaust, driven by steam power, was fitted up very extensively therein, which was wholly inefficient; and the same mechanism has been recently removed from the Mitchell Public Library there on account of its proved inefficiency.

St. Thomas's Hospital Plan, 1784.

An interesting and instructive essay was made in 1784 by Mr. Whitehurst, of Derby, to ventilate St. Thomas's Hospital, in London, by cutting away an inch and a-half of each pane in the bottom of the upper sash of every second window, and setting a frame of glass across the window, at a little distance from it, resting on the top of the lower sash and fastened to it by hinges, so that the frame could be adjusted to a greater or less angle with the window, in order to admit more or less air at pleasure. The air thus entering between the glass frame and the window sash was supposed to be thereby directed towards the ceiling, and diffused through the rooms. No means appear to have been provided for removing the exhausted air.

An arrangement almost identical was found in the windows of the Mitchell Public Library of Glasgow, when I recently reported to the Town Council Committee upon the state of its ventilation, and the means of remedying its defects. Judging by the 34 volumes in 10,000 of carbonic acid found in its atmosphere by the late Dr. Wallace, the city analyst, as the result of the combined operation of the inlet window frames and the outlet exhaust which has been already referred to, it may be safely concluded that the supposed diffusion of fresh air in the wards of St. Thomas's Hospital, by means of the window frames without the exhaust, did not yield so great benefit to the patients as Mr. Whitehurst desired and aimed at.

Sir Humphrey Davy's Scheme, 1811.

In 1811, Sir Humphrey Davy set up and put into operation the most notable of all the schemes essayed from time to time for the effective ventilation of the House of Commons, by admitting the fresh air through numerous apertures in the floor of the House, and carrying off the foul air by tubes in the ceiling, heated to promote rapidity of upward discharge, especially on occasions when the House was full; whilst all the windows, &c., were kept carefully closed.

This is the first instance on record of a carefully thought-out and matured scientific process for producing systematic renewal of the atmosphere of inhabited interiors, by balancing entrance and exit of air, with the entrance from a low level, where it would immediately supply oxygen to be breathed by the occupants, and with all irregular entrances for air closed up, whilst the exit was from the highest level, without any vestige of a foul air chamber, but by direct action, perpendicular tubes or flues, with an upward current superinduced therein by rarefaction by heat, so as to carry off the products of respiration, vapourisation, exhalation, combustion, &c., which ascended to the top of the chamber by reason of their expansion. Notwithstanding its unfortunate and calamitous failure, due to the then nebulous condition of the knowledge of applied mechanics and of the law of atmospheric diffusion, it was a creation of genius, the first embodiment and illustration of the fundamental principles on which alone effective renewal of the atmosphere of our rooms can be accomplished which places this distinguished man in the undeniable position of the father of the science of ventilation of inhabited interiors. The practical defects in his mechanism led to the subsequent adoption of scheme after scheme in which these sound principles were widely departed from, schemes predestined to irretrievable failure in consequence of the principles on which they claimed to proceed being directly at variance with atmospheric law, and the science of ventilation, thus evolved by the genius of Sir Humphrey Davy, has been perverted and turned back for three-quarters of a century by this crucial departure from the true principles laid down by him.

The names associated with the repeated attempts, and as repeated failures, to supply

a system of ventilation to the Houses of Parliament, which should fulfil the essential conditions so clearly enunciated in the report of the Commissioners already referred to, are those of men of great distinction, and a word is called for in support and justification of dealing so plainly with the demerits of their respective schemes; especially as most of these have been not only defective in their practical appliances but, unlike Sir Humphrey Davy's, unsound in their principles of action. Science honours the achievements and reveres the memory of her greatest sons, but does not hesitate to set errors of practice in a clear light, or to condemn departures from true principles. *Magna est veritas et prævalebit*, and in the ultimate court of appeal, in the scientific world, truth alone can prevail; error, wherever found, must succumb.

We have, in Glasgow, a repetition of this same plan, with the same failure in effective action, arising from the like mechanical defects. When I inspected and reported on the condition of the ventilation of the Corporation gas-office, I found that the gratings fitted into the numerous apertures in the floor for the admission of the fresh air had been nearly all carefully covered over by nicely fitted squares of waxcloth, because the occupants had found the draughts occasioned by the passage of the air upwards unbearable; and the upright outlet tube rising from the ceiling, although of very considerable height and sectional area, was found to be throttled, both at its entrance and its exit, in a very ingenious manner, whilst in several parts it was not perpendicular but horizontal, with abrupt bends and other serious defects, so that it was rendered incapable of taking off a fraction of the vitiated air that would otherwise have escaped through it; and similar defects are matter of every-day observation and experience.

A History of Error, Defect, and Failure.

What is still to follow of the history of the science is, like what has preceded, a history of error, defect, and failure, and some might be disposed to ask, what good purpose, then, is to be served by pursuing that history further? Much every way. Great names have been used to bolster up false methods, authority has been substituted for scientific deduction, and general assertion and eulogy for proof and demonstration; whilst essential error has been covered up and concealed by a misuse of rounded periods in the place of essential detail and accurate description. The public has thus been and is still being misled on a subject the practical importance of which cannot be overestimated, with the deplorable result that the houses of the poor are festering dens of atmospheric pollution and contamination, giving rise, in the worst cases of the modern development of overcrowded city populations, to an amount of physical deterioration inconceivable, and decimating them with a death-rate frightful in its enormity.

At the same time, as I can show from authoritative statistics, all classes of the community are participants in this great evil, with its consequent low vitality and resulting disease and death. The places of assembly of the fairest and most distinguished will be found to be as bad, in their essential defects, as the hovels of the poor; our court-houses, churches, public libraries, art galleries, scientific and philosophical societies, theatres, concert-rooms, lecture-halls, school-rooms, exchanges, all swell the list. The Houses of Parliament themselves, after two centuries of labour and an expenditure so colossal as to be almost incredible, are yet, notwithstanding much admirable mechanism, with a skilled supervision of the highest order, very far from answering to the fundamental and essential conditions, viz., the continuous, abundant, and imperceptible renewal of the atmosphere, the crude and unscientific expedient of opening the windows, and causing irregular currents to blow through the House of Commons, having still to be resorted to in the intervals of any extra long sitting. The existing apparatus for interposing a barrier to the entrance of fog is in many respects admirable, and with some simple, subsidiary arrangements would prove quite effectual. Yet the fact that the last dense fog not only effected an entrance, but, once in, refused to depart, and left the House for a long period shrouded in darkness, afforded to the ordinary senses an incontrovertible proof that the outlet apparatus is defective and unsatisfactory.

Mr. Barry's Scheme of 1847.

The most striking of all the illustrations of these observations is furnished by the singular scheme introduced into the Houses of Parliament by Mr. (afterwards Sir Charles) Barry, in 1847, and the still more singular lecture by which it was heralded, wherein its arrangements were praised "as beautiful appli-

cations of a philosophical principle;" but which proved, when put into operation, as unsuccessful as its predecessors.

It would occupy too much time to give the so-called description *in extenso*, and I therefore invite attention to the following short summary:—A warming apparatus was placed "beneath the public lobby, transversed by a quantity of air tubes, through which the air was passed; this current of warm air was conducted beneath the impervious floor of the lobby, then beneath that of the House of Peers, then beneath the floor of the royal ante-chamber beyond, and lastly up a rising passage, until it reached a reservoir chamber at the summit of the building." This operation, how absurd soever, is all clear, being effected by the natural law of expansion by heat. "From thence," it is said, "the air was made to pass down into the apartments, and there distributed without draught;" further, that its "gradual and imperceptible diffusion" was attained "by a system of currents, caused by subjecting the air to inequalities of temperature;" and that, "descending by the walls of the building, it was cooled by windows, &c., and thus its velocity downwards increased." We are not informed how "the gradual and imperceptible diffusion" of the entering fresh air was to be attained by this system of currents, subjected to inequalities of temperature, increased in their unequal and unregulated velocity of descent, by the continually varying cooling power of large surfaces of glass in the windows, and finally poured down on the heads and shoulders of the occupants! The future course of the air is next described:—"Arriving at this low level, at which it is at once heated and deteriorated by respiration, combustion, &c., the air rises in the centre of the room, and passes through the ceiling into a foul air chamber, in connection with the chimney."

Throughout this description there is a bewildering vagueness and absence of essential information as to the forces relied on for the performance of the alleged operations. Either the fresh air, when it arrived at the reservoir chamber assigned to it at the summit of the building, contiguous to the chamber assigned to the foul air at the same high level, was warm or it was not, but had parted with all its warmth to the walls of the long tortuous passages through which it was conducted, so that it had become cold enough, and therefore heavy enough, to acquire initial velocity of descent; in which latter case, what purpose was served by taking it to the ceiling and thereafter letting it fall to the floor, to be breathed by the occupants there? If, on the other hand, it was warm, by what motive power was its direction to be reversed, so that it descends from its chamber in the ceiling, whilst the used warm air takes a diametrically opposite course, and ascends to its chamber in the ceiling? And by what means were these two opposing and contradictory currents of these two assumed separate bodies of air, fresh and foul, each of the asserted large volume of 10,000 cubic feet per minute, to be maintained in continuous, uninterrupted operation, without any admixture or intermingling, each keeping to that part of the apartment which is arbitrarily assigned to it, although the incredible assertion is made that "imperceptible diffusion" occurs at the low level assigned to it, and at that level only?

But the facts of the case could not be subjected to this process of necromancy, and turned out in actual experience in conformity with inexorable atmospheric law, for the moment fresh entering air leaves the pipe, or tube or flue, or chamber, that conveys it into the interior of a room it becomes a component part of the one indivisible atmosphere of that room, subject to no such fanciful subdivision into one body of fresh air, keeping by itself in a descending course all round the sides of the room, and another separate body of used air, keeping by itself like a magic pillar rising in the centre of the room, but solely to the universally operative law of gravitation, by virtue of which, if there be difference of temperature, the coolest and heaviest, whether fresh or used, if not already at the bottom, will find its way there, and the warmest and lightest to the top; and if air cool enough, and therefore heavy enough to descend, be introduced at the top of the room, or be cooled by windows, it will in its passage downwards refrigerate, and bring down along with it some of the warm impure air found at that high level, and cool and so cause to descend the carbonic acid gas, and the still more deleterious organic effluvia which rise with the other warm products of respiration, exhalation, &c., but recover ponderosity when cooled.

Accordingly, the system thus lauded was scientifically erroneous and practically a failure, and far from being an improvement on the noble conception of Sir Humphrey Davy of 40 years before, was a total retrogression from the sound principles embodied therein, although, unhappily, too hastily discarded on

account of the imperfections in the mechanical details; whilst the high-sounding phrase about the "beautiful applications of a philosophical principle" is itself unphilosophical, inaccurate, and misleading.

Historical Method Departed from.

This by no means completes the history of the science, but at this stage the historical method may be conveniently departed from, in order to show how the efficient application of the true principles of ventilation, brought to light by Sir Humphrey Davy, has been rendered easy by the present advanced state of mechanical and scientific knowledge, and how it is quite competent to keep the fresh entering air practically apart and distinct from the used vitiated air in that low part of the room where it is required for supplying its oxygen to be breathed by the inmates, and with the additional advantage of introducing it absolutely free from currents or draughts by a true process of imperceptible diffusion, whilst the vitiated air is regularly taken off from the high level to which it rises by its expansion.

First, let it be observed that ventilation belongs to the domain of science not to that of the fine arts; it is a problem not in architecture, but in physics—a department of scientific engineering and applied mechanics. It is, therefore, natural and antecedently probable that the inventor of the miners' safety lamp, who was the foremost practical physicist of his time, should have succeeded in that in which artistic minds, like those to whose genius we are indebted for St. Paul's Cathedral and the new Houses of Parliament, failed —in elucidating the true principles of the science.

Sir Humphrey Davy's Fundamental Principles.

The following are the fundamental principles established by the father of the science, stated in the form of substantive propositions, with the corollaries necessarily following upon them superadded, whether deducible purely from the principles themselves or revealed by the light of the fuller knowledge subsequently acquired.

First Proposition.—Thorough ventilation consists chiefly in two operations, the intimate and invariable correlation of which must be kept always clearly in view, viz., (1) carrying off regularly and constantly the air which has become heated, vitiated, and exhausted by respiration, exhalation, vapourisation, surplus animal heat, and the lighting apparatus when in use, and (2) introducing fresh, pure air in its place.

Corollaries.—(1) All methods which are limited to one or other of these two indispensable adjuncts are, *ab initio*, defective and devoid of title to the name of a scientific system.

(2) The apparatus for producing the double action must be capable of easy and immediate control, and of instant regulation to the degree of ventilation required under all circumstances, quite independently of wind or weather. Systems of exhaust which depend on the motion of the outer atmosphere are anachronisms; they are literally "as variable and inconstant as the wind."

Second Proposition. — The fresh pure air must be introduced at a level low enough to mingle with the coolest and best air already in the room, and yield its oxygen uncontaminated for the inhalation of the occupants; all irregular entrances for air, by open or badly fitting windows, doors, &c., should be closed.

Corollaries.—(1) The air thus introduced must be imperceptibly diffused and free from sensible current.

(2) Entrance doors should be in pairs, and on springs that one may close before the other opens. Windows should be double glazed, which prevents the downward currents caused otherwise by the large cooling surfaces of glass.

(3) In summer, means should be provided for cooling the air; in winter, for warming it before it is passed into the room. Means should be available for effectually preventing the entrance of fog and "blacks."

Third Proposition.—The most efficient means for carrying off the impure air is an upright shaft, containing a column of air rarefied by heat, communicating at its lower end with the room at or near the ceiling, where the heat and impurity are at their greatest, and at its upper end discharging directly and freely into the outer atmosphere, without the intervention of any foul air chamber or other impediment to the rapid, uninterrupted, upward velocity of the air in the upright shaft, and its continuous, full, and unrestricted discharge from the top.

Corollaries.—(1) As the efficiency of the apparatus depends on the heat being maintained, suitable materials or coverings must be used to avoid waste of heat, and produce

effective insulation and prevention of radiation.

(2) The upright shaft must be perpendicular throughout, smooth and free from all turns, angles or corners; its full sectional area must be maintained at every point in the shaft itself, and in any hood or cowl by which it is covered; such hood or cowl must be so constructed as not to hinder but to promote the continuous free discharge.

The quantity of air removed is determined (1) by the height and free sectional area of the upright shaft, and (2) by the difference between the temperature of the air within the shaft, and that introduced below to displace it. If the upright shaft is at a distance, the connections must be so formed as to conserve its full power of exhaust.

Fourth Proposition.—The inter-relation and balancing of the two processes, of admitting fresh air and removing exhausted air must be kept clearly in view in any scientific system of ventilation, because they act and react as cause and effect.

These true principles having been ignored, or only partially applied, from the time when Sir Humphrey Davy's system was discarded down to the present time, it follows as a necessary consequence that the systems which have usurped its place are, *ab initio*, unscientific and marred by essential error.

Description of New Method.

I will now proceed to describe the method which has been adopted for giving form and substance to the said abstract principles, with the additional and important specialty of introducing the fresh air for the first time by imperceptible diffusion in the greatest abundance.

Section I.—For the admission of the fresh air without currents or draughts, a dado, preferably about 3 feet in height, but which may be somewhat higher or lower to suit particular circumstances, is fitted at conveniently available parts around the room, with a narrow space between the dado and the wall, and on the top of the dado wire gauze or perforated metal is fixed in an inclined position, so that articles may not be placed upon it to impede its action. The fresh air is introduced into the dado space at a low level and in a lateral direction to promote diffusion, through a number of inlets from the outer atmosphere along the whole line. The total area of these inlets is proportioned to the area of the hot-air shaft, after mentioned, for carrying off the impure air. The total space enclosed by the dado, forming a fresh air chamber or reservoir being very much greater than the total area of the inlets from the outer atmosphere, the outer air, coming into this extended space, and entering in a lateral direction, as explained, thus loses its initial velocity, spreads itself slowly over the interior of the reservoir, gently percolates through the innumerable interstices in the wire gauze or perforated metal on the top, and insensibly permeates the atmosphere of the room by imperceptible diffusion, at the low level at which it immediately yields an abundant supply of oxygen to be breathed by the occupants. It is absolutely free from the current heretofore found to set in from the point of entrance of air to the point of exit of air, which has been so invariable as to have come to be erroneously designated an "atmospheric law."

The inlets for fresh air into the dado may be made where suitable direct from the outer atmosphere, or may be at the bottom of ducts, communicating with the outer atmosphere at a higher level, and brought down to the low level at which the air is admitted into the dado space. The admission is regulated by valves fitted into the ducts or into the direct entrances.

The air admitted in the heat of summer may be cooled by means of a frigorific mixture, inexpensive as to cost, contained in a vessel which is placed when desired in a space provided in the inlets or ducts, by which means the entering air passes over and around the refrigerator before coming into the dado space. The extent of cooling can thus be regulated, with ease and precision, according to the varying conditions of the outer atmosphere.

In winter the air admitted may be warmed by a heating surface of pipes fitted along the length of the dado. This heating process is under equally easy and simple control. Means are equally provided, where required, for purifying the entering air from fog and from "blacks."

Section II.—For carrying off the impure, exhausted air, the needful perpendicular column of highly rarefied air can best be supplied by means of a chimney of suitable capacity with a close-throated fire-grate; or by a connection, properly formed, with any existing perpendicular flue. There should be an opening in the room, at a high level, into an outlet tube communicating with the perpendicular column of rarefied air in the chimney, or upright flue. This communi-

cation may be made direct at that level, provided there is sufficient remaining height in the chimney above it; if not, the outlet tube should be conducted down to a low level, and the connection there made with the chimney, with a semi-circular bend, to avoid corners or sharp curves, which impede the velocity of discharge. In the case of a distant perpendicular flue, care must be taken to make the connection complete, direct, and properly insulated.

The close throat of the fire-grate or other entrance into the chimney, at the fire level, or the heating entrance into the distant perpendicular flue, must be just of sufficient area to permit the free passage of the products of combustion, but not to allow other air to enter from the room and cool the chimney, or upright flue. Its full power as an exhaust is thus maintained, and the current from the room to the fire heretofore experienced becomes non-existent.

Where a fire is not wanted at any time, as in summer, an arrangement of gas jets, with Bunsen burner, or other appliance to consume a large proportion of air and a small proportion of gas, which raises great heat at small cost and free from smoke, is fitted up behind the fire-place, to produce the needful expansion of the air in the chimney.

Section III. — When a suitable chimney or upright flue is not available, the same results are produced by a tube of sufficient area and height erected above a sunlight in the roof of the hall, in cases where both lighting and heating are desired to be effected by one means.

When lighting is not desired by such means, or where a separate heater is desired, to be used alone or as an auxiliary to a sunlight, a Bunsen burner, or other the like appliance, is fitted in the outlet tube at its lower end.

The height and area of the tube must be sufficient to give a column of air of such capacity as will carry off the exhausted impure air from the room in ordinary circumstances, with very little burning of gas, and keep the exhaust going efficiently, with the most crowded attendance in the room, by turning on the gas fully. The amount of air taken off by the outlet tube is effectively regulated by either or both of two means—the use of valves and the degree of heat produced.

The tube should be coated outside with a non-conducting substance, to prevent radiation and consequent loss of heat; it should also be covered on the top, outside, by a revolving hood that will prevent ingress of rain and promote free and full discharge. The best hood is one round-cowled and open-faced, in perfect equipoise, turning easily and accurately with the wind, fitted so as to be incapable of being displaced or put off its true balance.

The special circumstances of all weathers and climates can be met with the same ease and efficiency; the application of the system in Calcutta would be a potent factor in the adjustment of the present serious difficulty in connection with the annual exodus of the whole governing body to the hills.

Practical Application of the System.

I propose now to make such reference to the practical application of the system, in three important and widely differing interiors, as may serve to fill up some points of detail which could not conveniently find a place in the general description already given.

The system was first applied in the Bungalow bar of the Glasgow International Exhibition, used for smoking and drinking; 50 feet in length, 20 feet in width, and 11 feet in height; to the entrance of the outlet ventilating tubes = 11,000 cubic feet.

It was lighted by three Wenham lamps, utilised for heating three outlet tubes, 16½ feet in height, and 7 inches in diameter, widened out at the lower end. The point of exit of the products of combustion from the lamps was arranged to be about 10 inches below the entrance to the outlet tubes, but they were placed at first at double that distance, with a resulting velocity of discharge of 6 feet per second. On being raised to the desired position this velocity was doubled, thus taking off the entire atmospheric contents of the bar three times every hour, which was in accordance with the calculation made beforehand as fulfilling the requirements of the Royal Commissioners' Report, in order to produce perfect ventilation.

The fresh air was introduced by means of a dado, or air reservoir, the whole length of the bar, viz., 50 feet, 3 feet in height, and 6 inches in depth, containing 75 cubic feet of air. This reservoir was covered on the top by wire gauze, placed on a slope. The inlets into it from the outside were at the bottom, seven in number, equidistant, each 9 inches square, with simple valves for reducing the effective area of entrance of air to any extent. In these entrances metal trays, 9 inches long by 3 inches broad by 3 inches high, were placed on short legs to hold a frigorific mixture when required.

The entrance of air was from one side of the room only, and the apparatus performed its work perfectly, the entering fresh air permeating the entire lower part of the room.

It was antecedently arranged that the state of the atmosphere, before and after the application of the system, was to be tested by an expert. The report of Dr. Wallace, the City analyst, which contains the full details, is given in the Appendix. It shows that whereas before the system was applied the place had "a very impure and oppressive atmosphere," after its application the air was "renewed three times an hour, a degree of ventilation which more than satisfied the requirements of the case, giving continuously a practically unvitiated atmosphere without gusts or draughts. The bar was densely crowded." The results of one of the systems of exhaust dependent on the wind, in a contiguous part of the Exhibition, are also stated in the report as "representing very foul air."

The low building was an annex to another, double its height, with a tower very much higher still, but the round-cowled, open-faced hoods, placed on the top of each tube, prevented any interruption by the wind of the continuous action, and the sensitive lamps below were not affected over the whole period of five months to the extent of a flicker. During the day, when the place was not so crowded to overflowing, the tubes did the work required without the help of the lamps, On a hot summer day, when the temperature of other rooms in the Exhibition stood at 80° and upwards, one kitchen being 110°, the Bungalow bar was maintained throughout at 60°, with a very great margin of cooling power unused in the refrigerating apparatus. The frigorific mixture used was the waste ice and salt from the fishmongers' baskets.

The next application of the system was in the smoking room of the Liberal Club, in Glasgow, situated in a building recently constructed at a large expenditure, with special instructions as to the efficient ventilation of this room given by the building committee, and expressly undertaken to be thoroughly carried out. The resulting condition of the room was such that the members generally declined to use it.

A member of the Club Committee, Mr. Copland, C.E., was appointed to decide as to the efficiency of the new apparatus, which proved to his entire satisfaction, and to that of the other members of the committee and the members of the club. The room is $28\frac{1}{2}$ feet in length, 22 feet in breadth, and $11\frac{1}{2}$ feet in height, thus containing 7,210 cubic feet of air to be dealt with.

The diagram exhibited on the wall shows a ground plan of the room, and the position of the inlet ventilating dados or reservoirs, and of the outlet ventilating tube. These dados or reservoirs, two in number, although thus divided, were constructed on the identical plan set forth in the preceding description. Their position, relative to the outlet tube, constituted a complete innovation on the received doctrine and practice, which is that a current invariably sets in from the point or points of inlet of air to the point or points of exit of air, and that any portion of the room outside the line of such current must remain unventilated. But the received doctrine is founded on a misconception of atmospheric law, and the system of currents, which is matter of universal experience, is due not to natural law but to radical and universal error in the construction of the inlet mechanism.

The outlet tube is on the west side of the room, with the opening near the ceiling, the communication with the chimney being at a low level, by a semi-circular bend. The inlets are at the north and south ends, and one half of the entire room—north-east, east, and south-east—is unprovided with any inlet apparatus. But the permeation of the fresh entering air throughout the entire room by imperceptible diffusion at the low level where it is required to yield a plentiful supply of oxygen to its occupants, is complete and thorough. There is no draught anywhere in the room, and no current between the points of entrance and the points of exit, nor towards the fire, nor towards the mouth of the outlet tube except immediately above its orifice.

The area of the passage from the fire-grate for the products of combustion is 22 square inches, leaving 134 square inches, or nearly a square foot of area, for taking off the impure air. The upward current is continuous, full, and uninterrupted by any wind or weather, and there is no division in the chimney to keep separate the products of combustion and the air from the outlet tube.

There is a Bunsen burner ring behind the grate to keep the exhaust going when a fire is not required. The coal burned is much less than in an ordinary fire-grate, whilst the heating of the room is far more efficient, and any small coal or dross is quite suitable ; the cost of gas, when used, is small. The velocity of

discharge through the outlet tube without any heating is sufficient for a great part of the time when the room is only partially occupied. The minimum velocity with the heating is six feet per second, simply and easily raised to nine feet when desired, which renews the whole atmosphere three times every hour. It has been worked up to a greatly higher velocity as an experiment. It will be at once perceived, besides, that were even a greater degree of renewal of the air desired, this is simply a question of greater area in the outlet flue and chimney.

These results have been repeatedly and thoroughly tested and proved by gentlemen of the highest qualifications.

The first of the tests was made by Dr. Russell, medical officer of health for the City of Glasgow, and president of the Glasgow Philosophical Society, at the instance of the Town Council Committee, who are the governing body of the Mitchell Public Library, the ventilation of which, notwithstanding the trial of many schemes at much expense, is in a very bad condition. Upon Dr. Russell's careful examination and report that the apparatus produced the results claimed for it as herein set forth, I was engaged to prepare a completed scheme for the ventilation of the Library on my system, which has been approved, although financial and other reasons have delayed its application.

The second test was made by Mr. John Mayer, F.C.S., lecturer on science and secretary of the Glasgow Philosophical Society. Gas was liberated from two bottles, one of hydrochloric acid the other of ammonia, producing a white cloud, which floated in the atmosphere, showing its whole movements, and making, as it were, the air visible. This was done in every part of the room, from floor to ceiling, and demonstrated the fulfilment to the minutest particular of the conditions antecedently described and undertaken. There is no heating of the entering air, because the heating surface of the special grate introduced, in combination with a group of chimneys passing up one side, produces the requisite warming of the walls, and 60° to 65° is easily maintained continuously.

The concluding illustration of the application of the system is its installation in the Glasgow Stock Exchange, a palatial structure, of ornate style without and within. Its ventilation, with appliances of a style and finish suitable to the surroundings, has been accomplished to the entire satisfaction of the Building Committee. The large hall is 60 feet in length, by 50 feet in width, by 31 feet in height, containing 93,000 cubic feet of air.

Numerous methods had been ineffectually tried since it was erected 14 years since. Some years ago there had been erected, rising from the centre of the ceiling, an outlet tube, 3 feet in diameter, and 45 feet in height, but, through serious defects, the power of this large upright shaft, as an outlet, was destroyed. I raised the sunlight as near to the ceiling as possible, covered the small tube, which carries up its products of combustion into the interior of the large tube with asbestos sheeting, and introduced a powerful auxiliary Bunsen burner ring at the bottom of the large tube; covered the large tube over all its length with asbestos sheeting coated with non-conducting paint, and arranged for the removal of the unscientific cowl on the top, and the substitution of a round-cowled, open-faced hood.

For the inlet ventilation, I removed Tobin's tubes, 13 in number, shut up and hermetically sealed the windows, and got them fitted throughout with double panes, in frames about three inches within the existing panes. The dado, or air reservoir, was erected on the plan already described. It is put along the entire extent of the two outer walls, north and east, and has a total length of 110 feet, enclosing the hot-water pipes already there. My plans included the placing of a powerful stove, with a large heating surface, in the room, to be lighted, during the winter, early in the morning, and kept going vigorously till half-past ten, to keep up the warmth of the walls. The whole ventilation is shut off during winter, in the evenings, and not opened till just before business commences. Double spring doors at the entrances to the building, front and back, are another essential to my plan.

The working of this apparatus is identical with that of those already described, and it has been, in like manner, examined and approved. A lighted match can be carried from end to end of the 110 feet of the dado immediately over the top without being affected, as tested, among others, by Mr. Mayer.

The contractor who engaged to make the revolving cowl to remain always secure in a true perpendicular, found it impossible to carry out these requirements. The diameter is unusually large for a revolving cowl, and the difficulties in the way were great. In consequence, and as no other form gives the same free and unrestricted velocity of discharge, I was compelled to consider how these diffi-

culties were to be overcome, and have designed a mechanism that fulfils all the conditions, a diagram of which is shown on the wall. It revolves on a circular platform, running on ball sockets with a minimum of friction, with or without a central pivot, and with a second platform beneath, which comes into play on a second set of ball sockets, inverted, in the event of a high wind lifting the cowl, at any part, an eighth of an inch, thus keeping it always in true action, and secure.

This completes the description and illustration of this new system of ventilation.

Two of the Best Existing Systems.

I will now, very briefly, refer to two prominent instances of the best existing ventilating arrangements, those, viz., of the Houses of Parliament and the London Stock Exchange.

The Exchange has an apparatus for washing the entering air by means of jets of spray, which possesses the double merit of occupying extremely little space, and of being at once simple and efficient. In the Houses of Parliament the same result is obtained by more elaborate mechanism, which is equally efficient, but occupies a considerable extent of space. The arrangements in both for cooling the entering air in moderately warm weather are good, but not sufficient to meet the case of unusually warm, sultry weather, nor able, notwithstanding the considerable expenditure involved, to produce the effects attained by the simple, inexpensive little cooling boxes used last summer in the Glasgow Exhibition, which easily maintained the atmosphere of the room fitted with them at 60° Fahr. during the whole course of a hot, sultry day, when the other rooms stood at 80° Fahr. and upwards. But, indeed, it would be a source of felt discomfort, even of danger, under the present method of admitting air to the House of Commons, to venture to cool it down during a protracted sitting to 60° or even 65° Fahr., which is the proper normal degree for health and comfort, because, as the air is supplied from below through a grating which forms the floor of the House, it enters, of necessity, with a sensible current—an evil so common as to attract little notice under usual conditions, but to which members become increasingly sensitive under the exhaustion of a sitting extending far into the night; and as the impinging currents cannot be stopped without shutting off the supply of air, the only means of rendering them less perceptible to the senses, is to allow the temperature to remain at the abnormally high degree of 70° or even 75° Fahr. In the London Stock Exchange the remarkable expedient is resorted to of driving in the air at 100° to 120° Fahr., to compensate for the effect of the large cooling surface by which it is reduced to a normal temperature; but this an undesirable proceeding, which would be wholly unnecessary under a more scientific system. The Glasgow Stock Exchange, a diagram of which is exhibited, is arranged and occupied in a manner almost identical with the House of Commons, and there the air is introduced by imperceptible diffusion at a normal temperature, and with the most crowded House there is continuous comfort and freshness, with the atmosphere at 60° to 63° Fahr., and with never a breath of sensible movement on the entering air, thus enabling the members to carry on the most protracted operations under the most healthful conditions. To produce the same results in the House of Commons, by altering the existing apparatus, would be a matter of the greatest simplicity and ease, whilst still retaining the entire advantages of all the admirable mechanism at present in operation underneath the floor of the House.

The entering air is driven into the London Stock Exchange by revolving fans at all times, and this expedient is at times resorted to in the Houses of Parliament also. In this, I submit, there is essential error; such a method is diametrically opposed to the principal fundamental requirement of the Parliamentary Commissioners, viz., imperceptible action, in order to attain which it is not only inadmissible to employ force to drive in the entering air, but indispensable to deprive it of its initial velocity, and to subject it completely to the operation of the natural law of the diffusion of fluids.

For removing the used and vitiated air from the Houses of Parliament use is made of the capacious perpendicular shafts in the Victoria Tower, the Clock Tower, and others, heated by great fires, and put into connection with the upper chambers situated above the ceilings of the Houses. These upright shafts, rising to a height of from 200 to 250 feet, with a sectional area of 80 square feet, would, if the connections were properly made, constitute a power of exhaust which could scarcely be rivalled—certainly not surpassed—in the world; as will be fully appreciated, when it is remembered that a factory chimney of such height has a velocity of displacement of 80 feet per second

and upwards. But the power of exhaust of these magnificent perpendicular shafts is dissipated and thrown away by the extreme imperfections of the connecting flues, and it is in consequence of the resulting radical deficiency, in the working of the outlet ventilation, that resort is had to the undesirable expedient of forcing air into the Houses. If the foul-air chambers at the top of the Houses were dispensed with, and the connections made by continuous flues between the Houses and the upright shafts, with the full power of the shafts themselves, carefully conserved by properly constructed entrances thereto at the fire level, they would be rendered capable of doing all the work with complete efficiency and great ease, under the severest strain of crowded and prolonged sittings; whilst they could be placed under simple control, so as to work down to the least displacement required under circumstances of less strain; and, with the arrangements already suggested for the admission of entering air in the greatest abundance by imperceptible diffusion, the House of Commons could be kept always supplied with a fresh, agreeable, and invigorating atmosphere, and wholly free from currents or draughts, although it were sitting continuously day and night, and that even for weeks.

Atmospheric Laws.

In conclusion, there is a department of this subject to which chemists and other scientific men of the first eminence have devoted unremitting labour, and in which they have given us, as the result of these labours, an extent and degree of knowledge of the laws of the atmosphere, and of its component parts, quantitative and qualitative, in every description of inhabited interiors, which is complete, leaving nothing to be added.

This remarkable and exhaustive inquiry, commenced in France over forty years ago by M. Péclet, its originator, has been carried on by Morin, Gay Lussac, Pouillet, Gentilhomme, Cheronnet, Pottier, and many others in that country, and by Fairbairn, Glaisher, Wheatstone, Playfair, Box, and a host of others in this country, and continued down to the latest date, forming the authoritative basis for the statement that, in the system, or absence of system, of ventilation of the houses and places of assembly of the wealthy, the same radical and essential defects prevail which produce such deplorable results in the hovels of the poor.

It is manifestly impossible, within the limits of the present paper, to give any *resumé* of this mass of invaluable information and statistics.

The Parliamentary Commissioners, Glaisher, Fairbairn, and Wheatstone — whose report, issued in 1857, ten years after Mr. Barry's attempt, was amongst the earlier contributions to the statistics of the subject in this country—state with great clearness the necessity for some better and more scientific system, and point out "the evident necessity of a method of ventilation which shall be as continuous and imperceptible in its action as that which is created by the occupants of an apartment upon the air which it contains, and which shall carry off all impurities, which are the more injurious because invisible and accumulative, and subtle in their action upon the health of living beings subjected to their influence."

During the intervening thirty years, vast progress in the practical application of scientific principles has been made on the banks of the Thames, the Clyde, and the Tyne; yet the last scientific report, issued in December, 1888, by Dr. Bedson, Professor of Chemistry in the Durham College of Science, and his colleagues on the Newcastle Commission, tells us that methods of ventilation have had little or no share in this advancement, and that none of the systems produced up till now over that long period have fulfilled the indispensable conditions so clearly and authoritatively laid down in 1857. The reporters set forth the existing condition of matters with a degree of uncompromising courage and plainness which I should, personally, scarcely have adventured to make use of, when putting forward a new system claiming to fulfil these conditions. After referring to the acknowledged success achieved by engineers in the ventilation of mines, and the resulting aerial comfort of the men in the bowels of the earth, they proceed:—"Bring but 1,000 or 500 of these men to the surface, and there is only one place in which they may be kept for, say, two hours together in aerial comfort, viz., the open. Under this condition there is no building available. Ventilation has not been demanded at the hands of architects as it has at those of mining engineers. This is the simple explanation of the failure to supply it. Ventilation of mines is appreciated and secured, but that of public buildings represents the most bemuddled branch of human knowledge extant."

APPENDIX.

Report by Dr. William Wallace on Samples of Air taken on 26th May and 9th June, 1888, at the Royal Bungalow Bar, Glasgow International Exhibition, before and after being Ventilated by Mr. Hoey.

The "Bungalow Bar" is an apartment measuring 49 feet by 20 feet, and the height to the openings of the ventilators, introduced by Mr. Hoey, is 11 feet. The apartment thus contains 10,780 cubic feet of air.

On the 26th May last, I took a sample of air in "the Bar" at 9.20 p.m., and found it to contain 22 parts of carbonic acid gas in 10,000 volumes. Deducting from this the quantity naturally present in air, say 3·5 volumes, there remains $18\frac{1}{2}$ volumes of carbonic acid added by the breathing of the persons present, or by the combustion of gas—a very impure and oppressive atmosphere. The temperature outside was 49° Fahr., and inside 74°—a rise of 25°.

On the 9th June a sample of air was taken at 9.15 p.m., which was found to contain 10·2 volumes of carbonic acid per 10,000 volumes, or, deducting the quantity naturally present, 6·7 volumes, or not much more than one-third of the former quantity. The temperature outside was 53° Fahr., inside 63°—a rise of 10°. The rise of temperature pretty closely corresponds with the relative quantities of carbonic acid.

On both occasions "the Bar" was densely crowded, and M'Connachy's patent ventilators were open, but did not appear to be doing any appreciable amount of work. On the 9th June some vitiated air was gaining admission to three of the seven ventilating boxes introduced by Mr. Hoey, but probably did not affect the result to a serious extent so far as contaminating the air in "the Bar" is concerned, but it of course interfered prejudicially with the free entrance of the fresh air.

The outlet portion of Mr. Hoey's system consists of three tubes, each $16\frac{1}{2}$ feet long and 7 inches in diameter, and the openings of these are placed 20 or 22 inches above the upper portion of the Wenham lamps, from which the heated air escapes. This is, in my opinion, much too great a distance, and accounts for the comparatively low velocity of the air in the tubes, which was found to be 360 feet per minute, or 6 feet per second. I find, by calculation, that the three tubes at this rate entirely renew the air in "the Bar" in 37 minutes; and if the speed were increased to 12 feet per second, which could easily be done by raising the lamps, the air would be renewed three times an hour; a degree of ventilation which would more than satisfy the requirements of the case, and give continuously a practically unvitiated atmosphere without gusts or draughts.*

On the 9th inst., a sample of air was taken by my assistant from Queen Mary's Room, in the Bishop's Castle, at 8.20 p.m., or twenty minutes after it had been shut up for the night. The carbonic acid amounted to 33 volumes in 10,000, or deducting, as before, $3\frac{1}{2}$ volumes, there was a net increase of $29\frac{1}{2}$ volumes, representing very foul air. The temperature was 74° Fahr. inside, and 53° outside—a rise of 21°, but it must have been much higher while the visitors were present. In this case the carbonic acid is due entirely to the breathing of the visitors, there being no artificial lighting of the buildings. I understand that this apartment has been recently ventilated, but apparently with no appreciable result.

WILLIAM WALLACE.

City Analyst's Laboratory,
138, Bath-street, Glasgow.
June 13th, 1888.

* The lamps have since been raised to the position at first desired by Mr. Hoey, and with the desired result.—W. W.

DISCUSSION.

The CHAIRMAN said all would agree that sufficient attention was not paid to ventilation in the construction of dwellings, but there had been many scientific inquiries on the subject, and much accurate knowledge had been gained; and he could not help expressing his regret that Mr. Hoey had so sweepingly condemned all the ventilation of the past without having made himself fully acquainted with what had been done. He had quoted Sir Humphrey Davy, but had omitted all reference to the able men who, during the last 100 years, had acknowledged and acted on those principles which he laid down. He alluded to Sylvester, Sir Joshua Jebb, Goldsworthy Gurney, Morin, Dr. Percy, and many others. If Mr. Hoey inquired, he would find that many places were ventilated on the principles he had laid down; that the system of passing air through a small aperture into a larger space, so as to diffuse it before it was allowed to enter the room, was adopted more than 30 years ago in barracks, and also that of removing foul air from the upper part of the room by non-conducting flues opening directly into the open air. The system he had described was almost identical with that by which that hall was ventilated, fresh air being introduced by a dado round the side, and the foul air being taken away by a shaft at the top. Still this paper was most interesting, and there were many points in it deserving of most attentive consideration, especially the remarks on double doors and windows; and the large revolving cowl, if it thoroughly answered the purpose intended, would be of very great value.

Mr. E. C. ROBINS agreed with the Chairman that Mr. Hoey had not given a complete history of his subject, but so far as he had gone he had been remarkably clear and precise, and the principles he had laid down seemed perfectly sound. The general rules to be observed and the results to be aimed at were generally acknowledged, but differences arose in applying these principles in individual cases, differences which were not always foreseen, and which sometimes led to failure. Still there were many successes which could be referred to, and Mr. Hoey's system could hardly be described as a novel one. He might perhaps describe the ventilation of that hall,

which was carried out under his supervision, and that would show how little novelty there was in what had been described. One point in connection with that room was the necessity of preserving the pictures from the dirt of the outside air, and that was effected by canvas screens, which were placed in the five large openings in the north wall through which the fresh air was introduced; these screens were changed from time to time as they became charged with dirt, and it was found that on an average a week was long enough to allow them to remain. The air then passed up behind the wall-screen or dado of the room by channels, which enlarged in width as they ascended, and opened into a long channel the whole length of the wall, from which it issued through a grating. In the winter it was warmed by gridirons of pipes which were disconnected from the general apparatus for warming the room. He quite agreed that fresh air should not be introduced through small orifices, but by an extensive surface, and so generally become diffused without draught. The next point was the extraction of the foul air at the top. The sun burner in the centre was used for ventilating the central dome; but there were four circular openings in the flat of the ceiling, through which the hot and foul air was drawn through zinc tubes and conducted into a shaft at one corner which rose above the roof, and in that shaft were placed hot-water pipes, at high pressure, which created a draught. This method had been in operation some six years, and he did not consider there was any novelty in it then, as it was based on principles with which architects had long been acquainted. Thirty years ago he commenced ventilating in that way, and could point to many public and private houses where the system was carried out, but always with the aid of heat to rarefy the air at the point of extraction or a fan. He might have referred to other buildings as well, both English and foreign, to show that Mr. Hoey had been a little too severe upon architects in the concluding paragraph of his paper.

Surgeon-Major INCE said ventilation was simply another name for the renewal of air, and it seemed to him that this so-called science was another of the peculiar fads of the modern science of sanitation. All this elaborate apparatus for ventilation was invented by engineers and architects seeking a means of earning their daily bread, and was one of the effects of the subdivision of labour.

Mr. W. SMARTT did not wish to say anything against the ventilation of that room; but in winter time he thought that some must have experienced a cold draught, but that possibly might be avoided by placing additional doors outside. He thought it resulted in some measure from the draught at the top of the room being more powerful than the warming apparatus at the inlet, and probably that would be the case with the system recommended in the paper. He regretted that Mr. Hoey had not referred to the system of ventilating and warming barracks, introduced many years since, with which he believed the Chairman was very well acquainted. He understood that the cold air was brought in from outside round the sides of an iron tube which passed up the centre of the room, and was admitted at the top, and after being used passed through the fire and up the chimney. A system of that kind might very well be adopted in many places where an elaborate system, such as that described, could not be applied. Mr. Hoey had not described how small houses and rooms could be ventilated, which he thought was quite as important as the case of large buildings.

Mr. ROBINS said he found that amongst working-class dwellings the old-fashioned thatched cottages were the best ventilated. When the paper was read by Mr. Emden on the construction of theatres, he had mentioned a method of construction in which closely woven wire was used for the walls, which would have the advantage of allowing the free admission of air without any currents.

Mr. W. STORR said that it was perhaps not altogether a disadvantage that Mr. Hoey was imperfectly acquainted with some of the efforts that had been made to improve the ventilation of private rooms and public buildings, because, with more complete knowledge, there might have been less of the enthusiasm that was necessary to concentrate attention upon the special development which was the outcome of his own study and experience. As one whose duty it had been to attend many meetings and gatherings in public rooms, he was painfully conscious of the vast injury that was done to health by the vitiated atmosphere that people were compelled to breathe. He had some knowledge of a palatial establishment, built with great solidity and without limitation of cost, in which gas-lighted rooms that were in use all night were hermetically sealed save when a door was opened; and when the neglect of the architect was partially repaired by the admission of a little air, there was no corresponding outlet for the products of combustion, so that the workers were nightly poisoned through the bad ventilation of a building where one would have expected to find the best arrangements that could be devised. It was true that the condition of the House of Commons was often unsatisfactory. This might be due partly to the great heat of the gas above the painted glass ceiling. The central lobby had often been intolerable from the warmth of the air with which it was supplied. The writing rooms, in which the reports for the newspapers are written out, had often been in a condition that would be condemned by an inspector of factories or an inspector of nuisances. This had been partially remedied in one room by the introduction of the electric light. As to the House itself, the substitution of a ventilating dado for the perforated floor covered

with open matting was not quite so simple a matter as the putting of a dado in the Glasgow rooms, the plans of which were exhibited, because there was a gallery on every side of the House, and the members' seats were in tiers, sloping upwards from the central floor, so that the top back seats were close under the galleries. There were galleries, too, in the House of Lords, and in many chapels and halls, in none of which could a dado be introduced in the same manner as in a large open exchange. The dado seemed to be a thoughtful development of what had long been known as the Tobin principle, the application of which experience had shown to be defective, where the velocity and volume of the air entering by an upright shaft made it felt inconveniently and unpleasantly. The local heating of the fresh air might do very well in large rooms of simple plan; but the problem was very different in buildings containing many rooms, like the Houses of Parliament, where steam-driven fans could scarcely be dispensed with. The Tobin plan, he believed, was introduced into the Leeds Town-hall and Assize Courts, and it was generally understood that the ventilation of the Courts and rooms gave satisfaction. One of the most elaborately-ventilated buildings in the country was St. George's-hall, Liverpool, with its large hall, concert-hall, assize-courts, grand jury room, and many smaller rooms. The entrance steps were flanked by stone blocks. One was hollow and covered with a grid. Below was a jet of spray, just filling the entrance to a passage. This spray washed the air sucked in by steam-driven fans, which, with engine, boiler, and copper-heating apparatus, were under the floor of the large hall. Beneath it on all sides were two-storey passages, with traps and valves for directing and regulating currents. The fresh air entered the hall in many places at the sides. The courts and minor rooms were supplied with fresh air by concealed passages and shafts, like those under the floor of the large hall; and the arrangements were such, that any room could be connected or disconnected at will, so that sometimes one, sometimes another, sometimes all were being supplied with fresh air, drawn in and forced onwards by the action of fans. In like manner all the rooms were connected with the up-cast shaft for drawing off the vitiated air. It was a question whether machinery could be dispensed with in so large a structure with so many rooms; but it might be that dado diffusers would be an improvement upon tubes and shafts, through which the fresh air had sometimes entered the courts with such force as to irritate judges and counsel, whose varying requirements could be met only by placing valves under their own control.

Mr. COLE said his father was the architect of the Stock Exchange, on the ventilation of which he should like to say a word or two. He did not complain at all of the way in which it had been spoken of in the paper, but would point out that in a building of that character the use of fans was indispensible. The "house" was surrounded by buildings on all sides; it was a tradition of the Stock Exchange that it should be shut off entirely from any street, and therefore it was necessary to have some force to compel the air to go where it was wanted. He quite agreed that fans should be avoided where possible, beeause it was undesirable to introduce the air forcibly or rapidly if you could do it gently. As to the hermetically sealing of doors and windows, it would be quite impossible at the Stock Exchange, owing to the rapidity with which people were constantly passing in and out. There was a very ingenious door adopted in Berlin, consisting of three or four arms revolving in a cylinder, so that as one person came in and pushed one door one way it closed the other. That would do where there was only a moderate traffic; but it was tried in London, and they found so many people were injured, that it had to be given up. Some of the members, too, used to play tricks, getting a man in between two of the arms of the door and wedging him in. Theoretically, no doubt, it was very good to hermetically seal the windows, but his opinion was that, however good the ventilation was, if you could open all the windows when business was over and give the place a thorough blow out, it was worth doing. As to the use of shafts for exhausts, they were useful sometimes, and they had several at the Stock Exchange, heated by Bunsen burners, but there were difficulties with them, and you could get more power from a small fan than a very large shaft. The recent advances in electricity, and in the supply of it which they hoped soon to see, might enable them to use small electro-motors, and place fans in positions where it was impossible to use them a few years ago; and that might perhaps help very much in exhausting the air from complicated buildings. In Vienna the systems of ventilation employed were most elaborate and costly, but as far as he could judge, the principle was sound. There the air was introduced at the top and drawn off at the bottom, the whole of the work being done by fans; and in America also he understood that method was adopted to a considerable extent. As an architect, he could not help saying that architects were not only acquainted with art, but they were obliged also to know something of science. Sir Christopher Wren had been mentioned, and it certainly was not his fault that he did not know what was known now, for he was one of the most advanced scientific men of his time.

Mr. J. OSBORNE SMITH remarked that there was an objection to the vertical inlet tubes, especially for small rooms in residences, which often led to their being stopped up—there was always a direct rush from them to the fire, and thus they could not be used when they were most wanted. The principle of distributing the air so as to bring it in with a thin film was much better than that of isolated tubes.

He had been surprised to hear Mr. Hoey say that he could pass a lighted match along the top of the grating without the flame being deflected by the current; if that were so the purification could only take place by the principle of the diffusion of gases, for if the air came into the room at all it must come in with some velocity, which would naturally affect the flame. He knew that draughts did occur from Tobin tubes, and he should imagine that a person sitting in a room with a fire in it would feel the air rush by him, even from these gratings, to the fire-place.

Mr. Pridgin Teale said Mr. Tobin was a fellow townsman of his, and he soon heard all about his vertical tubes. He adopted them in his own room, and found the inconvenience which had been mentioned, that the air came in in a cold cascade, and, moreover, a great quantity of dirt came in also. The latter difficulty he obviated by introducing canvas screens, which could be changed from time to time; but after a time he heard of an apparatus called Harding's "Diffuser," by which the air was introduced near the ceiling, and came through a screen which could be placed at different angles as might be required, and having had one of them fixed, he had been able to sit in his room, 14 ft. × 14 ft., for several winters, and had never felt a draught. So long as care was taken to change the screen whenever it got dirty he never had any soot except what came through the windows, though he lived in the middle of a large town.

Mr. T. C. Townsend said he was present at the opening of St. George's-hall, Liverpool, where the ventilation was certainly very good, but it could not be compared with the ventilation of that room. The more attention that was paid to ventilation, both in the case of public and private buildings, the better it would be for the public.

The Chairman having proposed a vote of thanks to Mr. Hoey, which was carried unanimously,

Mr. Hoey, in reply, said he was not unaware of the different systems which had been referred to. He thought he knew as much as could be known of the subject from reading, and was acquainted with every system which had been published, but of course he did not know what had been done by various gentlemen in their private practice. With regard to that room, he was delighted to find that it was ventilated so far in accordance with the principles he had endeavoured to lay down, and it certainly came nearer than anything he had seen in other places to what ventilation ought to be. Still he did not think it perfect, and it was not free from draughts as his was. The present discussion reminded him of a friendly controversy which went on in Glasgow in the Press for a month, at the conclusion of which he was compelled to ask how it was, if the principles were so well known, that all the churches, theatres, and concert-halls were in such an insufferable condition as regards the atmosphere when full of people; and how did they account for the condition of the theatres of London. He concluded by offering to give £50 to any local charity if any of his friends could show him one building that was ventilated as its ought to be, and yielding such results as he had produced and now described, which ended the controversy. He was not there to criticise the ventilation of that room, which was good, as compared with what is usual; the exhaust shaft would certainly have more power if the heat were applied at the bottom of it instead of the top, and he thought it would be better if the inlet were not so high up the wall. He certainly did not intend to depreciate the ventilation of the Stock Exchange, which was also good when so compared, and so was the House of Commons, notwithstanding what had been said about it. With regard to the ventilation of small houses, he should have been glad, had time permitted, to go into the subject; he had written upon it, and should be glad to furnish the gentleman who referred to it with a pamphlet. The plan adopted at Vienna of bringing in fresh air at the top was radically wrong; why should you take it up there and then have to bring it down again; it was putting the whole thing upside down, and was contrary to the principle of Sir Humphrey Davy, which he had endeavoured to act upon. Galleries in a building would offer no difficulty whatever; air was a gas, and it would diffuse itself according to the same law in every respect.

Miscellaneous.

RICE CULTIVATION IN PERSIA.

Rice is cultivated in all parts of Persia wherever water is abundant. It thrives well near the rivers and perennial streams, in the hot lowlands at the head of the Persian Gulf, all over the plateau of Persia, at altitudes varying from 1,000 to 8,000 feet above the level of the sea, and best in the lowlands forming the southern littoral of the Caspian. It may be said that all districts in Persia which possess a river or a perennial stream produce rice. A great part of Central Persia, and almost the whole southern littoral, extending from the head of the Persian Gulf to the frontier of independent Beluchistan, are devoid of rivers, and do not produce rice. The United States Consul at Teheran says, in his last report, that some of the great rice-producing districts are:—1. The districts of Fars, which are intersected by the Kara-Aghâch River and its tributaries, by the rivers which flow into the lakes of Nairîs and by the Shâpûd and Khishk Rivers, which, like the Kara-Aghâch River, flow into the Persian Gulf. 2. The district of Lenjân, near Ispahan, with more than 200

villages. It is watered by the Zayendehrûd River, and supplies nearly the whole of Central Persia. 3. The districts of the north-western province of Persia (Azerbaijan), which are intersected by the Kizil-Uzain and the Ajî-Chaî and their tributaries, and those on the Lake of Urûmîak, particularly in the neighbourhood of Marâgha. 4. The southern littoral of the Caspian, consisting of the province of Gilan, Mazanderan, and part of Ashâbâd, intersected by numerous rivers, which flow from the northern slopes of the Great Elburz Range down to the Caspian. 5. The district of Meshhed in Khorasan, watered by the Kashafrûd, the river of Meshhed. The most important of these districts is the fourth. The greater part of the cultivation of Gilan and Mazanderan is of rice, and those provinces are on that account very insalubrious in summer. The traveller Chardin observed about 200 years ago that one of the modes of expressing one's hatred to an enemy was to wish him to be made Governor of Gilan, as that province was most subject to malignant fevers. Rice is divested of its husk by small hand-mills of stone, and is then further cleaned by a machine called *dang*. This machine is moved by water power in Mazanderan and Gilan, in Senjan and some other districts, but in towns generally, in a more primitive manner. The machine consists of a heavy beam of wood, which swings vertically on a fulcrum like a see-saw, and is armed at one end with a hollow steel cylinder a foot long, and fixed at right angles to the longitudinal section of the beam, at the other end with a counterpoise. The machine works as follows :—Four or five men jump on to the end of the beam with the cylinder, their weight makes the beam descend, and the cylinder at the end is forced into the rice. The rice is kept in a tank about four or five feet in diameter, and four feet in depth, and constructed in the ground, its aperture flush with the surface, and is mixed with coarsely powdered rock salt to increase friction. The men then jump off the beam on to a platform at the side, and the counterpoise at the other end of the beam raises the end with the cylinder. The fall of the counterpoise is arrested by a block of wood, and as soon as the men hear the thud of the counterpoise on the block, they again jump on the beam, go down with it, and jump off it. The five men on the beam receive for twelve hours work a day, during which they go up and down 120 times an hour, 2½ krans, that is ½ kran, or about 3½d. each, and their midday meal. Many families clean their rice at home by putting it, together with rock salt, into a stone mortar, and pounding it with a wooden pestle. This practice is principally followed in the South of Persia, and in the province of Arabistan, at the head of the Persian Gulf. The work is always done by women, and the families of small communities generally combine. The best rice produced in Fars is the *champa*, with a long grain, which was introduced from India, where it was originally cultivated at Peshawur. Another kind grown in Fars is the *shahu*, with a round grain similar to the *girdeh* of other districts. The Ispahan districts produce principally the round rice called *girdeh*. The best quality of Mazanderan rice is that called *amberbu* (amber-odoured), with a small oval grain. The next quality is the *sadre*, with a long and thin grain, somewhat like the *champa* of Fars; the next the *girdeh* with a round grain. Other kinds are the *shahrek*, which is an inferior *amberbu*; the *zardeh*, a yellow coloured rice, also called *selimbegi* and *zardmaych*; the *raihani*, a strongly scented but inferior rice, and the *charmeh*. The amberbu now rarely appears in the market, the Sardre having almost completely taken its place. Of the other kinds only the sadre and the girdeh are exported, the others are kept for home consumption. The best Gilan rice is the akuleh, which has its name from the Akuleh district, where it was first cultivated; great quantities of it are also grown in Azerbaijan. The best rice of Azerbaijan is that of Maragha. A rice famous during the last century but now never heard of is that of Jemalbariz to the south of Kerman. Rice is an important food of the people, and Consul Schindler says, "Calculated per head of the population, most rice is consumed by the Mazanderan, but it must not be supposed, as some travellers wish it to be done, that the Mazanderanis eat rice only. It is true that they eat little or no bread, and it is commonly reported that a Mazanderani cannot digest bread, and would die if he were to eat bread alone for a couple of days."

Correspondence.

USE OF SPIRIT AS AN AGENT IN PRIME MOVERS.

When Mr. Yarrow's interesting paper was discussed, I pointed out that there would probably be a much greater economy of the spirit if it were burnt in the cylinder of the engine (as in a petroleum-engine), instead of being merely vapourised for expansion. Mr. Yarrow stated that in his system the consumption of spirit (680 sp. gr.) is about ⅓-gallon, or say 3 lb. per h.p. per hour.

In 1882, I took part in some careful trials which were made to determine the consumption of gasoline (sp. gr. 650) in an "Otto" engine, and we found it to be only 1·2 pints, or say 1 lb. per indicated h.p. per hour.

Three weeks ago a friend of mine made a trip on the Rhine, in a launch driven by a small "Otto" engine worked with spirit (sp. gr. about 700), and I am informed that the consumption was ½ kilo (= 1·1 lb.) per effective h.p. per hour.

In Messrs. Priestman's engine a cheaper and heavier petroleum product is used, and according to

Sir William Thomson's report, the consumption of this oil (sp. gr. 800) is 1·71 pints, or 1·69 lb. per effective h.p. per hour.

There is no doubt that for certain special work, and for small powers, Mr. Yarrow's system of propulsion has several advantages compared with steam, but compared with the results given above it is an extravagant consumer of fuel, and there is always great inconvenience, if not danger, attending the storage of considerable quantities of spirit of low specific gravity. I do not therefore see how such a system as Mr. Yarrow's can compete favourably for large boats or long distances, or even for short distances from places where there is not a supply of spirit at hand.

J. EMERSON DOWSON.

2, Great Queen-street, Westminster, S.W.
May 28th, 1889.

FOREIGN & COLONIAL SECTION.

Tuesday May 28.—In consequence of an unforeseen accident, the paper by Mr. O. B. SHALLENBERJER, on "The Westinghouse Alternating System of Central Station Electric Lighting in the United States of America," was not received from America, and the meeting was necessarily postponed.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, JUNE 3...Royal Institution, Albemarle-street, W., 5 p.m. General Monthly Meeting.
Engineers, Westminster Town Hall, S.W., 7½ p.m. Mr. Henry Faija, "The Forced Percolation of Water through Concrete."
Chemical Industry (London Section), Burlington-house, W., 8 p.m. 1. Mr. W. P. Wynne, "Naphthaline Derivatives of Technical Importance." 2. Dr. W. S. Squire, "Purification of Alcohol by means of Hydrocarbon Oils."
British Architects, 9, Conduit-street, W., 8 p.m.
Victoria Institute, 7, Adelphi-terrace, W.C., 8 p.m 1. Mr. W. F. Kirby, on "The Butterflies of South Africa." 2. Rev. F. A. Walker, "Niobe, or Neferura-Urmaa, the Daughter of the King of the Hittites."

TUESDAY, JUNE 4...Royal Institution, Albemarle-street, W., 3 p.m. Prof. E. Ray Lankester, "Some Recent Biological Discoveries." (Lecture III.)
Central Chamber of Agriculture (at the HOUSE OF THE SOCIETY OF ARTS), 11 a.m.
Chemical, in the Theatre of the Royal Institution, Albemarle-street, W., 8½ p.m. (Faraday Lecture.) Prof. Mendeleeff, "The Periodic Law of the Chemical Elements."
Biblical Archæology, 9, Conduit-street, W., 8 p.m.
Zoological, 11, Hanover-square, W., 8½ p.m. 1. Dr. G. J. Romanes, "The Intelligence of the Chimpanzee." 2. Signor Fr. Sav. Monticelli, "Notes on Some Entozoa in the Collection of the British Museum." 3. Mr. P. L. Sclater, "List of Birds collected by Mr. Ramage in Dominica, West Indies."

WEDNESDAY, JUNE 5...Geological, Burlington-house, W., 8 p.m. 1. Mr. Charles Candler, "Observations on some undescribed Lacustrine Deposits at Saint Cross, Southelmham, in Suffolk." 2. Mr. R. Lydekker, "Certain Chelonian Remains from the Wealden and Purbeck" 3. Prof. Joseph Prestwich, "The Relation of the Westleton Beds or Pebbly Sands of Suffolk to those of Norfolk and on their extension inland; with some observations on the Period of the final Elevation and Denudation of the Weald and of the Thames Valley."
Cymmrodorion, 27, Chancery-lane, W.C., 8 p.m. Mr. Owen Edwards, "The Marches (Y Gororau)."
Entomological, 11, Chandos-street, W., 7 p.m.
Archæological Association, 32, Sackville-street, W., 8 p.m.
Obstetrical, 53, Berners-street, W., 8 p.m.

THURSDAY, JUNE 6...Royal, Burlington-house, W., 4½ p.m.
Antiquaries, Burlington-house, W., 8½ p.m.
Linnean, Burlington-house, W., 8 p.m. Dr. F. Buchanan White, "A Monographic Revision of the Salices."
Chemical, Burlington-house, W., 8 p.m. 1. Dr. B. Bramer, "Experimental Researches on the Periodic Law." 2. Messrs. H. T. Brown and G. H. Morris, "The Amylodextrin of W. Naegali." 3. Messrs. H. T. Brown and G. H. Morris, "The Determination of the Molecular Weights of the Carbohydrates." (Part II.) 4. Prof. Emerson Reynolds, "Researches on Silicon Compounds." (Part V.) 5. Prof. Meldola and Mr. F. W. Streatfield, "The Isomerism of the Alkyl Derivatives of Mixed Diazo-amido Compounds." 6. Dr. Gladstone and W. Hibbert, "The Atomic Weight of Zinc." 7. Mr. R. Warrington, "The Amount of Nitric Acid in the Rain Water at Rothampsted, with Notes on the Analysis of Rain Water." 8. Mr. G. H. Morris, "The Product of the Action of Sulphur on Resin."
Royal Institution, Albemarle-street, W., 3 p.m. Prof. Dewar, "Experimental Lecture in Chemical Affinity."
Archæological Institution, 16, Burlington-street, W., 4 p.m.

FRIDAY, JUNE 7...Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting, 9 p.m. Dr. A. Geikie, "Recent Researches into the Origin and Age of the Highlands of Scotland and the West of Ireland."
Geologists' Association, University College, W.C., 8 p.m.
Philological, University College, W.C., 8 p.m. Mr. E. L. Brandreth, on "A Dictionary Sub-Editor's Work."
Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m.

SATURDAY, JUNE 8...Physical, Science Schools, South Kensington, S.W., 3 p.m. 1. Prof. S. P. Thompson, D.Sc., "A Method of Suppressing Sparking in Electric Currents." 2. Mr. E. W. Smith, "A Shunt Transformer." 3. Prof. S. P. Thompson, D.Sc., "Notes on Geometrical Optics."—(1) The deduction of the elementary theory of mirrors and lenses from wave principles; (2) a dioptric spherometer; (3) the formula of the lenticular mirror; (4) the use of the focal circle in mirror and lens problems. 4. Mr. A. W. Ward, "The Use of the Biquartz."
Royal Institution, Albemarle-street, W., 3 p.m. (Tyndall Lecture.) Prof. W. Knight, "Idealism and Experience in Philosophy and Literature."

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FRIDAY, JUNE 7, 1889.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CONVERSAZIONE.

The Society's Conversazione is fixed to take place at the South Kensington Museum (by permission of the Lords of the Committee of Council on Education), on Friday, June 28.

Each member will receive a card for himself, which will not be transferable, and a card for a lady. No tickets will be sold.

The cards of invitation will be issued shortly.

Proceedings of the Society.

APPLIED ART SECTION.

Tuesday, May 14, 1889; JOHN HUNGERFORD POLLEN in the chair.

The paper read was—

VENETIAN GLASS.

By Dr. Giulio Salviati.

In accepting the invitation of the Committee of the Applied Art Section to read a paper on the manufacture of Venetian glass before this Society, I fear I may have undertaken too great a responsibility. It is a subject which, from its ancient and historical treatment, may suffer at my hands. I can only say I will do my best, and should the subject be inadequately presented by me, I shall beg your indulgence for all shortcomings.

I need not mention here the tradition of the first discovery of glass; we have all read of the Phœnician dealers in soda, who, while taking refreshment on the banks of a river, noticed with great astonishment that the amalgamation (produced by the action of their fire) of soda with sand and the herb alkali, had produced a transparent substance, which was afterwards purified and otherwise improved till it was converted into glass. How far this tradition may be true this is not the place to discuss, for I must confine myself to that specialty which is known as Venetian glass.

You are doubtless aware that Venetian glass is not actually manufactured in Venice proper, but at Murano. Venice being the most important and best known city, has always lent her name to the art.

Murano is the prosaic name of an island built on the north of Venice, from which it is distant about half a mile. It is said that the name was derived from the Latin words, *murus muralis*, but I believe the name has a more local derivation. The island being washed by a north-west current of the Adriatic sea, which by its ebb and flow continually removes the otherwise stagnant water of the lagoon, I think that the true derivation of its name is from *maris amnis*, which means "river of the sea," and in the subsequent changes of the language became Murano.

It is said that the reason Murano was chosen as the seat of the art of glass-blowing was on account of its peculiar geological position, which has no rival in Europe, and is only partially equalled by Reichenau in Bohemia.

The bed of the sea which washes the shore of Murano is composed in great part of quartz or silica, materials which are brought thence from the Alps in torrents. These materials or sand form one of the principal ingredients needful for the manufacture of Venetian glass. I may mention that some time ago the Minister of Public Works, on the request of the Chamber of Commerce of Venice, prohibited the use of this sand for any other purpose, and also prohibited its exportation.

There must be something peculiar in the natural position of Murano, as is proved by the fact that when the demand for the glass

increased almost beyond the capabilities of the restricted space at command, the Muranese did not think it advisable to extend their furnaces and works to the neighbouring islands. Not only is this restriction attributable to the natural position of Murano, but also to the personal peculiarities, in some measure, of the artists themselves.

They commenced their works naturally with the simplest forms used in daily life; afterwards, when they found a demand for something richer, more elaborate and complicated in design, they worked on step by step in their profession, discarding all use of moulds and contrivances for making easier and quicker their labours, intent only on perfecting their art works, and making every piece a real work of art, of which they are and always were extremely proud. So much do they identify themselves with their works, that there are certain forms and designs which are quite traditional. These have been handed down for generations from father to son, and are known by the family name of the artist producing them.

It would seem, from the variety and immense numbers of tints and shades, that a knowledge of chemistry would be needed in the formation of the base of this manufacture. Such, however, is not the case, as a reflection on the ignorance of this science 200 or 300 years ago will prove. This was about the time when Murano began to be renowned for her splendid productions, a renown which has been more or less maintained until the present day.

The artists had neither the time, nor the means, nor desire, to occupy themselves in chemical studies; but continual experiments and practice on certain traditional lines, together with patience and determination to succeed, are and have been the chief moving powers in their works.

Some time ago a celebrated professor of chemistry while questioning an old artist as to the manner in which he learned to make such an enormous variety of tints, asked him by what means he had arrived at such knowledge. The old artist told him that the grammar which he studied, and which was the key to all his success, was practice, and that he would defy the professor, with all his scientific skill, to produce the same colour as he had just then produced. He added that the Muranese artists were like the birds, who could sing without having learned music.

For certain compositions there are naturally secrets, which are kept with scrupulous care, and handed down from father to son either by example or by simple writings.

Owing to the extremely good feeling which has always existed between Murano and the city of Venice, the former was specially favoured, and received many honours from the "Queen of the Adriatic." In the year 1223 the doge and senators gave instructions that the names of the principal *maestri*, or heads of the glass-blowers, should be entered in the public records as being the names of persons to be held in high esteem and respected in the history of the republic. The senators and the Council of Ten established laws for the protection of the glass manufacture.

At the period of the Renaissance the works at Murano had reached such a point of perfection as to eclipse, by the originality and beauty of their productions, all the works in glass made by the Egyptians, Etruscans, and Romans.

The artists of this age were invited to and received at all the courts of Europe, and their works were universally proclaimed as exhibiting the inspiration of genius, and as doing the greatest honour to the industrial arts.

The Venetian government at this time was well aware of the immense moral and financial advantage which this manufacture brought to the country, and consequently took every precaution to prevent the secret of the manufacture from being learnt by foreigners, and the Murano workmen were absolutely forbidden to carry their skill beyond the boundaries of the island of Murano. Artists who were by any means seduced from their allegiance, and persuaded to accept employment in other parts of Europe, were visited with severe punishment, and in some cases by actual death, while the State rewarded those who, by special skill or otherwise, distinguished themselves, and who remained faithful to their country, the senate even granting them the privilege of electing a chancellor to administer justice at Murano. The Venetian nobility also did not think it derogatory to their position to marry their children with the children of the Muranese *maestri*, and the children born of these marriages retained all the privileges of the nobility.

But even to Murano this age of glory and prosperity was not to be perpetual. By and bye the "Queen of the Adriatic" declined, and the sunset of her political and industrial day caused the decadence also of her cherished and beloved neighbour, the island of Murano;

In the 17th century the artistic perception of form and colour was lost, and it was distressing to compare the heavy, shapeless, highly-coloured objects then made with the exquisite colours and graceful designs of past years. The darkness of night had succeeded to the light of sunny days, which appeared to be gone for ever.

The republic made several efforts to arrest this decay, by loading the artists with gifts and by granting them many privileges, also by imposing heavy taxes on the importation of foreign glass. Still the French and Bohemian glass had taken a strong position, and the continual purchase by Venetians of these wares contributed to the dying out of what until then remained of the production of art in Murano.

In the year 1700, when the art of glass-blowing was at its lowest ebb, Giuseppe Briasi made efforts to give new life to it, and being possessed of an indomitable will, and great perseverance, he endeavoured to restore the ancient beauty of form and colour, by producing some fine specimens of chandeliers, and candelabra, and vases, in which could be seen some remnant of the past glory, but the prevailing taste of the period, only served to injure instead of improving his efforts. His efforts were followed by others, viz., Bigaglia, Seguso, Barbini, and Mialti; but all suffered the same fate, and their labours were rendered futile by the prevailing taste of the time, and their labours resembled the last dying flicker of a candle previous to its entire extinction.

At last the republic died, and the art of glass-blowing at Murano, which had hitherto been guarded and protected by Venice, fell into lethargy, but it was not really dead nor even entirely forgotten. The elements of its existence and prosperity were not entirely dependent on political changes; and its traditions were bound up in the souls of the old artists of Murano, descending to their sons and grandsons, and it only required a fresh impulse to dispel the torpor and gloom in which it was sunk.

It was the pleasant duty of my father, Dr. Salviati, to give this first impulse and to raise the dormant genius, and give new life and energy to this lovely and brilliant art, with what success we all know. My father was a lawyer of good repute, and while exercising his professional duties at the Venetian forum, he spent his leisure hours in admiring and studying the sublime works left by his ancient compatriots. It grieved him that such lovely works should be doomed to oblivion, and in the year 1856 he conceived the arduous idea of reviving the mosaic art, and resuscitating it from the tomb of the past. He read and studied all books relating to the manufacture of gold and coloured enamel, and having associated himself with Lorenzo Radi, of Murano (an artisan who for many years had occupied himself in studying the manufacture of the first material necessary for mosaic), he relinquished his profession of the law and dedicated all his energies and fortune to the development and perfection of the gold and silver and coloured enamels for the manufacture of Venetian mosaic.

Their first joint attempts were so successful as to deserve the highest encomiums from the Royal Academy of Fine Arts in Venice. A committee, consisting of painters, sculptors, and architects, was chosen from members of the academy, to carefully inspect, examine, and report upon the enamel produced by my father. After carefully examining, they declared that "the gold, silver, and coloured enamels produced by Dr. Salviati are even superior to the enamels of ancient times." It is not within the scope of this paper to give a history of the revival of mosaic by Dr. Salviati, nor a *résumé* of the various failures and successes by which the result was obtained, only to say, that this discovery of the means of making the enamels was the first step in the revival of the art of glass-blowing at Murano, as it was whilst so occupied that Dr. Salviati was persuaded to attempt also the restoration to Venice of this lost art. He was much helped and encouraged in the enterprise by Mr. Norman Shaw, one of the chief ornaments of his profession as an architect, who was quick to perceive that my father possessed the needful element of perseverance for this revival. He was also ably helped and advised by the late Mr. E. W. Cooke, R.A., the late Sir Gilbert Scott, also by Messrs. Clayton and Bell, and others, who saw in the revival of mosaic a hope that the glass industry might also live again.

My father never ceased to express how grateful he always felt to these gentlemen for their artistic advice and help to him, and for their very valuable councils and encouragements, which helped him to persevere and conquer the apparently insuperable difficulties in his path.

The composition of the first material needful for the manufacture of mosaic has many of the qualities necessary for the production of the Venetian glass composition, hence it was

an almost certain conclusion for a man with the energy and determination of Dr. Salviati not to rest satisfied when the difficulties of mosaic were conquered until those of the glass were also surmounted. It was no easy task to train the glass blowers, and to make them forget the clumsy and heavy productions to which their hands had become accustomed, and to resume the light and elegant forms of the past times when Venice showed so great a pride in her artists, especially when we consider such lessons had to be given and received before a burning furnace, and then, even when success crowned their efforts, there were many disappointments. I need not enumerate the numerous difficulties which had to be met and overcome before Dr. Salviati was in the proud position of being able to say, "Now again is Venice famous for her blown glass and mosaics."

The glass blower of Murano is no mere mechanic or artisan, he is in every respect a true artist, an artist endowed with the perception of beauty and genius, who invents and creates daily new forms and colours. The glass is to him what the chisel is to the sculptor, the brush to the painter, and the works he produces are the offspring of his talent, and the perfection of form, delicacy of colour, and lightness, are his hobby, and when, after several arduous trials, he succeeds in producing a splendid specimen of his art, all the fatigue is forgotten in the legitimate pride and pleasure with which he looks upon it and says "This is mine."

Under the name of "Venetian glass" is comprised not only the elegant vases and goblets and ornamental objects, but also chandeliers, candelabra, mirrors, table glass, and roundels of sheet glass for windows, &c., for which Venice was famous.

There are a number of names used to express the various kinds of glass, thus:—The "ritorto," a kind of stripe of different colours on a plain ground; the "fiamma," a mixture of many different colours, so named from its appearance of flames; the "retticello," which represents delicate lace patterns; the "aventurine," looking like brilliant gold; the "festoncino," having the appearance of threads; the "chalcedony," looking as its name signifies, like some stone or marble, &c. These various compositions all require different treatment, many needing several days in preparation.

The tools used by the artists are few, and very simple, a hollow, long tube of iron for blowing, a large pair of shears for cutting (similar to those used by tailors), a few other instruments for measuring, and a stamp with a strawberry-shaped die, these compose all the instruments used in the production of all the articles, even in a *tour de force*, which is the term used to express the most complicated designs. The production of a vase or other article is obtained in this way:—The end of the blowing-rod is dipped into a pot containing molten glass, and a portion of it accumulated on the end. It is essential that the quantity which adheres to the rod should be accurately guessed for the size of the vase or other object which it is intended to produce, be it a small wine glass or a large tazza. If the quantity taken up is too small, the article produced will not be of sufficient size, and naturally if too much is taken, the article produced will exceed the required dimensions. This lump of liquid glass is then rolled on a table by giving a few turns to the blowing-rod; it is then blown by the artist slightly, then re-heated in the furnace. This process is repeated each time the article takes a more definite shape, until after repeated heating and blowing, the lump of glass is blown into a vase, cup, or other article. During the whole operation the artist remains in front of the furnace, as the material must be kept in a liquid condition until the right form and size are obtained. Having thus made the body of the object, the artist now proceeds to form the foot or stand. In this he is assisted by another artist of an inferior grade, who has prepared meanwhile a piece of the necessary material on a blow-pipe, and who has blown it hollow. This he keeps in a liquid state, and in order to prevent it from dropping off his pipe he has to continually turn it round and round. The right moment must be watched, and then the two parts are joined; a twist, a pull, and a little dexterous manipulation, and the stem is formed. The article is again placed in the furnace; meanwhile the maestro, or chief artist, takes up a small portion of another coloured material, then, taking the article from the furnace, he proceeds to ornament it with strawberries, flowers, leaves, or other devices; between each operation the article is introduced to the furnace to keep it soft; of course it has to be carefully held in shape. It is astounding to see the numerous variety of decorations which the artists produce for the embellishment of the objects. There are serpents, dragons, flowers, leaves, handles, &c., nothing is too complicated or simple,

one and all are modelled by these instruments. Some vases require the attention of four artists at the same time, and require from one to two hours of uninterrupted labour. During this time they are placed in and out of the furnace thirty or forty times. While they are in the furnace they have to be kept iu position by a special artisan called a "forcellante," whose duty it is to keep the article turned round and round, and who must watch that it does not drop or any way lose its form; for this purpose he uses a long fork-like instrument, this he has to do standing in front of the mouth of the furnace until the article is sufficiently cooled to retain its shape without assistance; then by slow degrees it is introduced further and further into the cooler part of the furnace where it remains cooling until the following morning. The painter and sculptor know how difficult their art is, and how much practice they must go through before they can draw a model accurately. How much more difficult, then, must it be for an artist to have to mould his subjects from the pliant and semi-liquid glass, and to be obliged to work at such a speed as to prevent the glass from cooling too much for manipulation.

This general process of blowing is applicable to self colours, such as opal, ruby, acqua marina, &c.; but when the object to be produced is to be made of the richer and more complicated wares, such as the reticillo, ritorto, filagree, &c., then the material requires a separate preparation, which process (according to the material required) takes from one to three days. These are prepared in long strips called "canna," and when covered with crystal and ready are placed side by side on a kind of shovel, which is put into the furnace; as they melt they adhere to each other, and the workman with a piece of half-melted glass on the end of his rod presses on the ends, then with a dexterous twist he winds them all up into the form of a cylinder, the end of which is fixed to the handle that is to control them during subsequent operations. When thus ready, the artist dips the end of his blow-pipe, charged with the cylinder of prepared strips or canna, into a pot or ordinary clear glass, which is to protect the delicate lace work or the sensitive aventurina. He then proceeds to roll them on the marver or little iron table, and when by heating, rolling, and blowing, they form a compact, body he proceeds to cut off a piece of the required size, taking care that the strips are all evenly joined. The vitreous mass thus obtained is then treated by the artist in the manner I have already described to you, and he proceeds to fashion his jug, vase, glass, tazza, or other object. The pattern which was thus imprisoned in the small strips is now by blowing fully developed.

If no twisted movement has been given during the operation, the lines of lace-work or other work remain straight; if, on the other hand, a different movement has been given during the process, the lines will have a twisted effect, as is often seen in Venetian glass. The filagree is prepared by minute thread-like strips enclosed between two sheets of crystal glass; the threads are sometimes crossed, and then minute air-bubbles are imprisoned between the two sheets of glass, having a very beautiful effect when completed.

The "fiamma" is prepared thus:—Upon a hollowed and rolled lump of material are laid strips of avventurina and other colours which are to form the "flames," which are wound spirally round; they are then heated, and whilst in the oven, and before the fusion has proceeded very far, a sharp-edged piece of iron is drawn across them several times, so that there are ridges both ways on the mass, which gradually amalgamates into one piece. On coming out of the fire, the object is subjected to extra twisting beyond that necessary to give it its proper form.

The "millefiore" is a lengthy process. First there are strips made of a certain pattern according to the taste of the artist; these strips are encased in clear glass cut up into lozenge-shaped pieces, then laid on a surface of any coloured glass desired to form the ground work of the contemplated article, the whole is then heated and blown, developing as it proceeds, the pattern contained in the small lozenges on a clear or coloured ground, producing a lovely effect. By this process all kinds of designs can be produced, animals, insects, and even portraits, distributed all over the vase, jug, or other form. A portrait is formed by the artist taking several strips or canna of the requisite tints, and putting them together in a similar way by which a mosaic portrait is made; this is, as may be imagined, a very delicate and difficult operation. When thus arranged they are covered with a thin coat of crystal, which serves the double purpose of keeping them in place and of preserving them; the mass thus prepared is then inserted into the furnace, and when it commences to melt, two artists, each having an iron tube with a piece of molten crystal on the end, take hold of the mass, one

at each side, they move very quietly in opposite directions, which has the effect of elongating the round strip, which is stretched longer and longer until it presents a long thin round strip, which has been kept firmly in place by the coating of clear glass, and which preserves perfectly the portrait all through. This strip of prepared canna is then cut into very thin lozenges and used the same way as in the previous preparation, being used to ornament plates, jugs, goblets, &c.

The avventurina is a metal preparation produced by the fusion of various component parts; this is a material used to give the exquisite brilliancy and lustre so much admired in Venetian glass; it is a very difficult and tedious process, and exceedingly uncertain in its results. This process is one of the chief secrets of Venetian glass, and is only known to one or two of the maestri. It is said the name "avventurina" is derived from adventure, on account of its always uncertain results. The use of a little more or less heat than is absolutely necessary, or some other cause (mostly inexplicable to the most experienced artist himself), will cause the whole mass to be a failure, after three or four days' labour. Instead of being the brilliant avventurina the artist expected, he finds on opening the oven a mass of a composition of a dull brick-like colour.

The avventurina is used not only in the glass-blowing, but also in the jewellery when it is cut and polished. When used in glass-blowing, a great amount of care must be exercised, and it must be protected by a covering of crystal, otherwise all the sparkling effect would be lost.

The fires used in blowing Venetian glass are made of wood, coal being useless on account of its generating too much smoke and gas, which prevent the delicate ornaments used in decorating the various objects from adhering. Ornaments and vases made by *coal* or *gas* alone would soon separate into their various parts.

The artists are from their entrance allowed a certain time daily for study, during which they design and create new shapes and colours. In this of course some are more skilful than others. They work together in the greatest possible harmony, each one aiding the other to develop and perfect any new idea, and the interest with which they all anxiously await the moment when a new shaped vase or a new combination of colour is to be withdrawn from the oven is surprising. There seems no personal jealousy, every one is equally as interested, from the youngest boy to the oldest man. They perfectly understand the capabilities of each one among them, and when the vase, or tazza, or other object is to be made, each artist immediately prepares for his individual part; thus, should the object required be of unusual dimensions, it is at once undertaken by those men who have the strongest lungs for blowing; again, should it be an exceptionally fragile and delicate vase, it is undertaken by the artists known to have the lightest hands; the most difficult forms, such as griffins, dolphins, birds, &c., being the special work of certain artists only. I do not think it is easy to find such harmony as exists between artists employed at Murano. I can say that I never heard an angry word among them, and all mutually help one another; they are more happy when at work than when having holidays. These they are obliged to take during the end of July or August, when the furnaces are allowed to go out. The temperature being excessive, it is found impossible during this period for the men to work, so this opportunity is taken advantage of to build new furnaces.

There is one dreadful circumstance which they must all face, and this is blindness. It is unhappily the fact that nearly always, after many years of work, and when they are between forty and fifty years of age, they begin to lose their sight, and after a little while they can see no longer. There is no means of preventing this; it is caused not only by the excessive heat, but also by the glare of the continual flames. Many things have been tried, and several kinds of protection for the eyes, but without avail.

Fortunately, when the dreadful event occurs, they have not the additional suffering of want to face, for while at work their wages are very high, often surpassing those of their magistrate, and their mode of life simple. They thus save large sums, and their declining years, if passed in darkness, are at any rate of ease and comfort in other respects.

I will now conclude my paper by simply stating that it is now over 25 years since this beautiful art of Venetian glass-blowing was revived by my father, and that it has continually progressed in form and colours, the always increasing demand for it, not only in this country, but in France, Germany, America, and indeed all parts of the globe where people are cultivated and appreciate works of art. Its cost, as you can understand,

now that I have told you how each piece is made, is naturally greater than that of those glass articles which are moulded, but then its beauty is equivalent to its value.

DISCUSSION.

The CHAIRMAN, after expressing his regret at the unavoidable absence of Dr. Salviati, said that the avventurino, which was frequently mentioned in the paper, was the gold glass in which the gold was produced by means of copper, and when the glass was heated too much the brilliancy of colour was lost. He had seen vases made in which the lace-like work was introduced in the following manner :—The workmen took a number of canes and put them into a pot with a little sand to keep them in place, and then dropped a piece of hot glass kept till it had sufficiently warmed the different canes, when they all adhered, after which they were pinched with the pinchers, and then covered with a little film of glass. They were then taken, while heated, and twisted and drawn out until fine lines were obtained. There was a great deal of truth in the statement that the artists at Murano did not know much of chemical science, but still there were certain broad rules of chemistry which had been in possession of mankind in connection with the manufacture of glass from a very early date. It was impossible to trace the story as to the first discovery of glass by the Phœnicians, and be had no doubt that the Egyptians were acquainted with the secret of glass-making some 4,000 years ago, as some very old specimens had been discovered in Egypt. The ancient Egyptians had a great reputation for producing sham jewels of a brilliant colour, and glass on a large scale. Alexander the Great was said to have been buried in a glass coffin, and there were stories of pyramids of glass 50 feet in height having been made. No doubt these pieces were cast in much the same manner that plate-glass now is. He thought there must have been a sufficient knowledge of chemistry in early days to inform people that by taking the oxides of such metals as copper, iron, tin, &c., different colours could be produced. In the Chinese collection at the South Kensington Museum there were some very remarkable specimens of coloured glass, in fact they were so beautiful that they might almost be mistaken for precious stones. These were of recent make. There were also some very interesting Persian specimens, which more nearly resembled Venetian glass than the Chinese. The difference in treatment, and the time the glass had to be exposed in the furnace, to produce different hues, were no doubt secrets which were jealously guarded by the trade.

Mr. H. J. POWELL, referring to the statement in the paper respecting the number of Venetian glass-blowers who became blind, said he did not remember a single instance in which the blindness of an English glass-blower could be said to be due to his occupation. He attributed the blindness of Venetian glass-blowers to the fact that in Venice the men worked the glass in the flames of the furnace, whereas English glass-blowers worked by the heat of a covered crucible, and were thus shaded. Practically, the same material was now being worked at Whitefriars as was used in Venice, and there was no difficulty in working it in a covered crucible, so that he could not see why this process should not be adopted in Venice.

Mr. A. PAYNE inquired whether in England the design of an article was left to the workmen, or copied from a drawing.

Mr. POWELL replied that the workman almost invariably worked from a drawing or pattern.

Miss WEBSTER said that in the South Kensington Museum there was a tazza ornament, with white glass enclosing a dead white separate ornament, and she should be glad to know whether the art of making this kind of glass was still known.

The CHAIRMAN observed that there were some specimens of glass of the same kind on the table, so that it would be seen the art had not been lost.

Mr. POWELL, in answer to Mrs. Ernest Hart, said the sand used at Whitefriars was obtained from Fontainebleau, in France, the peculiarity being that it was practically pure silica. Nothing approaching this sand had been found in England. This they used for all kinds of glass.

Mrs. E. HART said her reason for asking the question where the sand was obtained was because in Gweedore there was a bed of the very finest sand that could possibly be had for glass-making. The sand was used for this purpose about 100 years ago. The bed of sand was about nine miles from the sea-shore, and was somewhat difficult to get at. She should be very glad to forward a specimen of the sand to Mr. Powell.

The CHAIRMAN then moved a hearty vote of thanks to Dr. Salviati for his interesting paper, which was carried unanimously.

Miscellaneous.

DWELLINGS OF THE POOR.

The recent report (for 1888) of the Mansion-house Council* on the Dwellings of the Poor briefly summarises in less than five octavo pages the principal work it has done during the year. There follow

* The offices of the Council are at 31, Imperial-buildings, Ludgate-circus, E.C., where information concerning its organisation and work can be obtained.

seventeen pages of "general notes," in which, after reference to water supply and overcrowding, the unsanitary condition of parts of Bow, Poplar, Bromley, Camberwell, Plumstead, Westminster, and Rotherhithe are described. Appended is a reprint of the official report to the Home Secretary of the Commissioners appointed by him to inquire as to "the immediate sanitary requirements of Bethnal-green," and also a report of the public inquiry held by the same Commissioners into the sanitary condition of Rotherhithe. In addition to other matter there are also memoranda on sanitary laws for the guidance of local committees affiliated to the Council, of which there are thirty-one in different London parishes.

The concise report itself points to the urgent need of some such organisation as the Council. It acts "as the practical exponent of the recommendations of the Royal Commission on the Housing of the Working Classes," and is "the only society existing for compelling better sanitation of the dwellings of the poor."

The Commissioners in their report of 1885 said (p. 35):—"The remedies which legislation has provided for sanitary evils have been imperfectly applied in the metropolis, and this failure has been due to the negligence in many cases of the existing sanitary authorities." And again (p. 36):—"There has been failure in administration rather than in legislation. What at the present time is especially required is some motive power."

The Council endeavours to be practically what the Commissioners called a needed "motive power" for enforcing legislation.

In addition to information of details of cases dealt with, the volume refers in many places to the broad question of "sanitary neglect and administrative incapacity" (p. 7); to the local authority requiring "not only heavy pressure," but "educating as to its statutory duties" (p. 8); to a Vestry being "chiefly responsible for the neglected condition" of houses (p. 16); to the complaint of an officer of health that his inspectors were "utterly useless" (p. 23); to cases of sanitary inspection being almost totally neglected (p. 37); and so on.

On the other hand, among extracts printed are two which point to something worse than neglect on the part of tenants. One is:—"The experience of the Vestry (Rotherhithe) is that dust-bins, water-butts, and cistern-covers go for firewood directly they are provided" (p. 27). The other is that w.c. fittings "in many instances had been destroyed by mischievous children" (p. 48).

In the report of the Rotherhithe inquiry, the evidence of the sanitary inspector (p. 48) includes the statement, that the old property was so bad, that if repaired one week it would relapse the next into the same state.

The official report on Bethnal-green (p. 59) speaks of dilapidated houses as showing "defective roofs, broken floors, dirty walls and ceilings, broken plaster, dilapidated window frames, together with faulty gutters and defective pointing of walls, giving facilities for damp to enter." .... "Newly erected houses are necessarily free from many of the faults of those which preceded them."

On the important question how long new houses (of the kind intended for the wage class and the poor) remain free from faults, the report does not enter. The Council limits its action, since the scope of every society to be effective must have a limit, to dealing with houses which have fallen into an unsanitary conditon.

The definition "unfit for human habitation" has been taken by different sanitary authorities in different ways, and houses frequently reach the stage of being from a tenant's view "not fit to live in," long before they can from the the legally defined sanitarian view be pronounced "unfit for human habitation."

The stages by which Westminster cottages and gardens degenerated into "slum courts" was sketched in the *Journal* No. 1,727, and on page 985 of No. 1,823 brief reference was made to building in the suburbs. The recent degeneracy of many miles of suburban roads of newly-erected dwelling houses is evident. Most of these are not more than ten years old, and many are less.

It can easily be seen that it is the readiness with which everything "gives way" that has brought this about. The fronts of the houses, originally so smart, show how the mortar, even where in the ten years replaced, has so disintegrated that every strong wind blows it away, and rains wash it down. The edges of the bricks are consequently exposed, and the weather has rounded and, in some cases, broken or crumbled away from a quarter to half an inch. Each time the front is "repointed" the proportion of mortar required is greater. That window key-stones slip, cracks start, and window sills break is no wonder. Where there is a clay subsoil under the shallow gravel or surface deposit on which the foundation bricks are placed cracks running up the whole front are common. That a front four or five years old should need "doing up" is not regarded as strange, for as the bricklayers say, it is not easy to know how a new house will "settle." The "doing up" consists of filling up the cracks, putting fresh mortar between the bricks, repairing the plaster or stucco "architectural features" with more plaster or stucco carefully smoothed with a trowel, re-colouring the bricks, ruling off the lines of white, brown, or black that surround each brick, and then making the stucco or plaster bright with paint. Then in about a couple of years the front is as bad, sometimes worse, than before. As for the backs of the houses, as they do not show from the road, they are generally allowed to go on without any doing up. As a consequence of these cracks and the apparently naturally expected "settlings," windows and doors get out of square, "just a little out," as the bricklayers call it, and a carpenter's plane to "give just a shave" here and there makes them go easily again. After this has been repeated a few times there is ample play for

draught and the entry of dust. Then as to the interior. Since the woodwork, such as staircases, bannisters, handrails, window-frames, doors, wainscotting, &c., is generally taken ready made (the bricks being built to the wood), and is not of well seasoned wood, shrinkage sets in very shortly. Not only the paint shows this by the appearance of unpainted lines round window frames, door panels, and joints of all kinds, but a pencil can be put between the wainscot and the floors, and an umbrella point under the door. Locks, bolts, buttons, hooks, window fasteners (none strong to begin with), soon become useless, and it is to be noticed how many of these present sharp angles for tearing clothes unless they are carefully avoided. The joints of floors widen and the edges of the planks become uneven, frequently slightly curving up, so that the ordinary way of washing with flannel fills them with "fluff." The fire-places, when made of cement, as in the kitchens, the fixings of the sink, and of the washing copper, readily chip away. It is within the mark to say that not half the floors and passages can be found level, and this may be noticed in passages that have oil cloth that is worn into lines following the joints of the planks. These lines have been known to show in new oil cloth, down only for a few weeks, and in older cases the floor cloth is worn through. The same is seen with carpets.

When floors gradually bend, the cracking of ceilings is to be expected, so is the falling of plaster from walls, for the walls are of such material they hold only long nails, and a clothes line in a room needs very long shanked hooks. There are plenty of opportunities for seeing such houses without disturbing a tenant, as the notice "To Let" is frequently to be seen.

These observations have been made on houses not yet ready to come under the notice of the Mansion-house Council. They are in newly built suburbs. And the building of such is rapidly progressing. Already it can be seen that the careless state in which they are kept by tenants corresponds with the careless way in which they were built. A seriously interesting problem is how long will it be before they are as neglected and as disintegrated as houses recently pulled down in recognised "slums."

CERAMICS IN CATALONIA.

The United States Consul of Barcelona, in his last report, says that hand-moulded bricks occupy, beyond all dispute, the most important place among the various industries comprised under the general denomination of ceramics, both on account of their numerous and important applications, as well as of the large number of labourers employed in their manufacture. The process is of the most rudimentary nature, both as regards the moulding and the baking. The moulding is done on a large uncovered brick floor, where in the event of a fall of rain the work of many days would be ruined and rendered useless. The baking is performed in ovens constructed near the moulding floor, the intermittent system being employed. The importance of this industry in Catalonia is very considerable, on account of the large exportation of the articles to the island of Cuba, where, however, special shapes are required. The process of manufacture consists in a rough sieving of the clay, which being kneaded is placed in wooden or iron moulds. This, as before mentioned, is done on an uncovered brick floor, where the moulded bricks are left until entirely dry, being frequently turned to obtain this result as quickly as possible. When dry they are carried to the ovens, where they are piled in castle shapes, with intermediate spaces sufficiently large for the free access of the flame to all parts of the pile, thus producing an even baking of the bricks. Besides the common type of bricks others are occasionally made and baked in the same oven, especially those called Roman tiles. These, which were formerly used throughout the country are now everywhere discarded, on account of the cheapness and lighter weight of the mosaic tiles which have taken their place. A short time ago the manufacture of floor bricks constituted a very important industry in Catalonia, and although now, on account of greater exactions of style and luxury, it has somewhat lost ground, it still holds a high place among the Catalan industries. The bricks, which are five and a-half inches square, are of two kinds, white and red. The clay used is of the best quality. The kneading of the clay, which is done very carefully and completely, is performed by hand, as is the case with the moulding and cutting of the bricks into their definite shape. The bright red colour is obtained by applying before cutting a bath of barbotina (worm seed) to the bricks, selecting for the purpose a special kind of clay, very plastic, of a bright red colour. The floor bricks which have acquired the most fame abroad are those manufactured at La Brisba, a small town near the city of Gerona, where the clay is of a particularly excellent quality. The manufacture of machine-made tiles is considerably developed in the province of Barcelona, where two important factories turn out a large amount of work. The material used is a plastic clay or marl of a yellowish colour, which, after a thorough baking, whitens considerably. Formerly the clay used came exclusively from the mines of the towns of San Saturnino de Noya and Gelida, about thirty miles from Barcelona. The clay in powder having been sieved, is kneaded by means of an apparatus with blades disposed in screw shape, whereby the cake is obtained out of which the tile is manufactured. The moulding is performed by means of a pressure machine, the main feature of which is an iron cylinder of hexagonal shape, having on each face the shape of the upper side of the tile, and

against which, on revolving, a workman applies a cake of clay, a definite shape being obtained from the matrix, which contains a mould of plaster or delf with the imprint of the lower side of the tile. The tiles, after being dried, are piled in the oven and baked. In one of the large factories in Barcelona there are two large continuous furnaces (Hoffman system); in another they bake their tiles in square ovens where fire is used intermittently. Both factories use hard coal for fuel. An important industry, not so much on account of the number of usages to which they are dedicated as for the great number manufactured, is the making of glazed bricks for kitchens, the shape and condition of which in Spanish cities is well known to consist in a number of small iron furnaces or grates, at a certain height from the floor, set in masonry, to cover which the above-mentioned bricks are used. These, the manufacture of which is almost exclusively confined to Catalonia, are used throughout Spain, the Philippine Islands, and the Spanish colonies in America. In mosaics there are two distinct kinds, both used as flooring, one of which, the older, is obtained by the juxtaposition of numerous pieces of geometrical shape, and each of a different colour. The inconveniences of this kind of flooring consists in the difficulty in making surfaces perfectly smooth on account of the different thickness of the pieces, and the fact that as soon as one piece is out of place the whole flooring requires re-setting. Nevertheless, at one time the manufacture of this kind of mosaic was at a great height, and constituted an important industry. The difficulties already mentioned, and the restriction which the geometrical shapes of the pieces imposed upon the general design, have given rise to the manufacture, in modern times, of incrustated mosaics. In this, as in its sister industry, natural clays are used, preference being glven to those with a large quantity of alumina, on account of the great heat of the ovens heated by hard coal. The colours are produced by various metallic oxides mixed in proper proportions. In the manufacture of simple mosaics the several moulded pieces are obtained by means of pressure stamps, the matrices of which have the geometrical shapes to be given to the pieces. The baking is done inside boxes or cases of fire-clay, in ovens of only one laboratory and one or more fire-places. In the manufacture of incrustated mosaics all kinds of designs are obtained with the same clays used in simple mosaics, the difference consisting in the moulding, which, as in the previous case, is performed by pressure, but with larger machines, the dimensions of the pieces being larger. The shape is always square, with sides of two and a half inches or more. The designs are obtained by placing slips of tin within the stamp matrices, and each one of the intermediate spaces formed being filled with the different clays previously coloured. The designs thus obtained, the slips of tin are removed, and the whole rendered compact by pressure.

GERMAN RIVER AND CANAL TRAFFIC IN 1887.

The following information respecting the river and canal traffic of Germany relates to vessels and rafts navigating the undermentioned rivers and canals, and whose arrival or departure has been notified at the places specified:—On the Niemen, at Schmaleningken; the Vistula, at Thorn; the Canal of Bromberg, at the second lock; the Oder, at Ohlau; the Spree, at Berlin; the Elbe, at Hamburg; the Weser, at Bremen; the Ems, at Nieppen; the Rhine, at Emmerich and Mannheim; the Sarre, at Gudingue; and the Canal from the Rhine to the Marne, at Altkirch (frontier of Alsace). The total traffic, ascending and descending, reported at the above places, attained the following proportions in 1887:—132,863 boats with cargoes, and 35,989 without cargoes, amounting in all to a total of 168,852 boats, with a tonnage of 28,577,000 tons, against 157,722 boats, with a tonnage of 26,210,000, in 1886; and 146,378 boats, with a tonnage of 22,951,000, for the average of the years 1881 to 1885. M. Hewin Belle, the French Consul-General at Frankfort on the Marne, from whose report these particulars are taken, states that previous to the year 1881 there were no complete returns relating to German river and canal traffic. The weight of goods shipped on these boats amounted in 1887 to 17,568,000 tons, in 1886 to 16,002,000 tons, and for the average of the years 1881 to 1885 to 14,318,000 tons. The increase in the general movement at the places mentioned above, in the year 1887, as compared with the average of the preceding years was, for the number of boats, 15·4 per cent.; for the capacity of the vessels, 24·5 per cent.; and for the quantity of goods shipped, 22·7 per cent. The tonnage of the rafts passing the localities in question amounted in 1887 to 2,217,000 tons, in 1886 to 2,061,000 tons, and for the average of the years 1881-1885 to 2,313,000 tons. Compared with the last figure the falling off in 1886 was at the rate of 11·1 per cent., and in 1887 4·4 per cent. Berlin, Hamburg, and Emmerich are the most important centres of German river and canal navigation. For Berlin the movement was as follows for the year 1887:—Ascending 2,564,000 tons, and descending 1,665,600 tons. As regards Hamburg, the total quantity of goods going up the Elba increased from 438,000 tons (average of the years 1872-1875) to 1,247,000 tons in 1887, or 18·5 per cent. The weight of goods descending the Elbe and arriving at Hamburg, rose during the same periods from 256,000 tons to 1,321,000 tons, an increase of 41·7 per cent. Finally, in the case of Emmerich, the transit going up (goods coming from the Netherlands), which amounted to 818,000 tons, the average for the years 1873-1875, rose in 1887 to 2,226,000 tons, or an increase of 172·1 per cent., and the quantity going down (goods with a destination of the Netherlands), which amounted to 1,554,000, tons —average for the years 1873-1875—rose to 2,730,000 tons in 1887, an increase of 75·7 per cent.

THE STRAW PLAIT TRADE.

At the Glasgow International Exhibition last year, the manufacture of Italian and English straw hats, as carried on at Florence and Luton, was illustrated at a special stall, at which Italian and English workers showed this particular handicraft. The special feature of this exhibit as stated, was, that it was the first time that Leghorn hats had ever been manufactured in the British Isles.

In a description of these manufactures circulated at the time of the Exhibition, a sketch of the rise and fluctuations of the straw plait trade is given. In official documents relating to Florence, so far back as 1575, there are references to the "Corporation of Merchants of Straw Hats:"—"Fifty or sixty years ago the staple article of export from Italy was the 'fioretto,' or broad brimmed flop hat, and known as the Leghorn hat. This name is now given to all hats of the same material and manufacture, whatever their shape or dimensions may be. The plait of which this hat was made was of thirteen ends, and the strips were knitted 'a maglia,' as it is technically termed, namely, sewn together without overlapping, so as to form a single piece, a method of manufacture confined to Italy. The many valuable qualities of the Leghorn have always been greatly appreciated in this country—the beauty and strength of its tissue, the brightness of its colour, its lightness and comfort in wearing, the ease with which it can be adapted to various shapes, and its moderate price."

Leghorn hats are produced entirely in the province of Tuscany, the straw being grown there, plaited, made into hoods or capelines, and mostly shaped in the district.

The straw is produced by planting the corn five or six inches deep in a very poor soil, mostly chalk. It grows very fast during the warm weather of the early spring, and in the hot Italian summer the straw soon attains its full growth, and assumes that bright colour known as Tuscan. It is then harvested, collected, and sorted by machinery, consisting of a series of sieves which separate the various qualities. After this process the straw is arranged in small bundles for market, the great depôt being Empoli.

The plaiting is done by people of all ages, from children of tender years to very old persons, and by both sexes. It is a curious and interesting sight to pass through the country from Florence to Empoli, or Florence to Prato, passing through Lastra, Signa, Campi, Brozzi, and other towns which form the seats of this industry. In the summer whole groups of people may be seen plaiting in the shade, a perfect hum of conversation going on all the while. In spring or autumn the work is done while strolling about in parties of half-a-dozen or more, full of gossipy talk or fun, while in winter the parties are just inside their houses, sitting round a large open charcoal fire, and should a stranger pass by there is a general rush to note him.

The process of making the plait up into hats is done by a special kind of sewing, which consists of a series of secret stitchings, the needle passing between the straw, so that the thread is invisible. When the "capelines," as they are called, are finished, they are collected and sold to the large dealers. A capeline is described as a hat which has been formed from the plaits sewn together, but before being bleached and shaped. The bleaching is principally effected by exposure to the sun, after which the hats are ready for export. Though these hats are made in the before-mentioned districts, and sold in the markets of Empoli and Prato, still Florence is the headquarters of the Italian straw trade. In this city every Friday (the market day) a motley crowd of buyers and sellers are to be seen in the ancient market hall grouped round the old bronze figure of "The Wild Boar of Florence." Provincials are to be seen in full country costume, generally in felt hats more or less of the brigand type, long cloaks, coloured ties (if worn at all), green and red being the favourite colours.

Leghorn hats, as they are called, were never made in Leghorn; they took the name of the place from its being the port of Tuscany from whence they were shipped. Railways and tunnels such as the Mont Cenis and St. Gothard are only modern events, consequently until comparatively recent years the only way of outlet was by the sea. Now the overland route is mainly taken advantage of, and these hats, though seldom near Leghorn, still retain their old name of Leghorn hats.

In England the principal seat of the straw hat manufacture is in Bedfordshire, probably because the best descriptions of plaiting straw is grown in that county. In the earlier years of the present century straw plaiting was a very considerable industry in Bedfordshire, as well as in Hertford and Essex. The plait was chiefly made in the villages by women and children, and also by many of the men. The common method of plaiting was with seven straws. The plaits used up to the beginning of this century were made of whole straw, and judging from the size of the hats and bonnets worn during the 18th century they must have been heavy and cumbrous articles of attire. About the year 1800 a method of splitting the whole straw with a knife into strips or splints was introduced, and by this means a lighter and more pliable texture was produced.

The quality of straw plait is determined, not only by the skill of the plaiter, but by the quality of the straw of which it is made. When ready for the market the plaits are collected by dealers, and by them taken to the neighbouring towns to be sold to the manufactures. The largest of these markets is at Luton, where spacious plait-halls have been provided for the accommodation of buyers and sellers. Previous to the erection of these halls the plait market was held in the principal street, the country people and their handiwork being exposed to all weathers. Up to a comparatively recent period the competition between foreign and home made plaits considerably developed the straw trade in England without very

materially injuring our English plaiters; and we may claim that the foreigners have at no time excelled our own plaiters in quality and design. John Chinaman has now, however, entered our markets with plaits of excellent quality, at such low prices as practically to exclude the lower class of English plaits from the markets, and to render the plaiting of even the better articles barely remunerative.

The importation of the Canton or Chinese plaits, while it has almost ruined the plaiting industry in England, has at the same time proved a considerable gain to the straw hat manufacturers in Luton. The cheapness of the raw material, and the enormous quantities poured into the markets, enable the manufacturers to supply the retailers with a useful article at a cheap price. This has led to a great increase in the demand, and at the same time to the introduction of improved and chemical appliances into almost every branch of the trade.

GREEK RAILWAYS.

The subjoined statement shows the progress made by Greece in the development of her railways. Eight years ago there only existed in this country the little Athens-Piræus line, ten kilometres in extent (kilometre = ·621 of a mile), while the country will have a a total length of line of 1,700 kilometres, when all the railways, the construction of which has been decided upon by the Chamber, are completed.

	Kilometres.
Lines in working:—	
Piræus-Athens-Peloponnesus	306
Attica	66
Athens-Piræus	10
Thessaby	204
Pyrgos-Katakolo	13
Lines under construction:—	
Mylo-Tripoli-Kalama	185
Patras-Pyrgos	104
Missolonghi-Aghrinion	44
Lines, the construction of which has been sanctioned by the Chamber:—	
Athens-Larissa	400
Pyrgos-Pylos	130
Pyrgos-Sparta-Gythion	183
Diacoftc-Kalaoryta	23
Missolonghi-Antirio	30
Total	1,698

Correspondence.

LIVERPOOL (VYRNWY) WATERWORKS.

My attention has been drawn to an article descriptive of the Vyrnwy Waterworks in your publication of the 17th ult., concluding with the following sentence:—"Mr. Deacon, who projected the work in 1877, having prepared the general plans, became joint engineer with Mr. Hawksley in 1879. In 1885 Mr. Hawksley retired, and the work has since been carried out by Mr. Deacon." This expression conveys an entirely wrong impression. The Corporation of Liverpool engaged me to be their engineer-in-chief in the year 1880, for the purpose of designing and superintending the construction of the Vyrnwy Waterworks, and at the same time appointed Mr. Deacon as resident engineer, to superintend the execution of my designs. As engineer-in-chief I designed all the important works of the undertaking, but mainly in consequence of my dissatisfaction with the manner in which they were being carried out, I resigned my position in March, 1885, and finally retired in September, 1885. Mr. Deacon never was a joint engineer with me after the passing of the Act of 1880, when the onerous duty of designing the constructions devolved on me alone.

T. HAWKSLEY.

30, Great George-street, Westminster,
4th June, 1889.

MEETINGS FOR THE ENSUING WEEK.

TUESDAY, JUNE 11...Royal Institution, Albemarle-street, W., 3 p.m. Prof. E. Ray Lankester, "Some Recent Biological Discoveries." (Lecture IV.)

Medical and Chirurgical, 53, Berners-street, Oxford-street, W., 8½ p.m.

WEDNESDAY, JUNE 12...Microscopical, King's College, W.C., 8 p.m. Mr. V. Ganson Thorpe, "Description of a New Species of *Megalotrocha* from Brisbane."

Royal Literary Fund, 10, John-street, Adelphi, W.C., 3 p.m.

THURSDAY, JUNE 13...Society for the Encouragement of Fine Arts, 9, Conduit-street, W. Morning Meeting.

Royal Institution, Albemarle-street, W., 3 p.m. Prof. Dewar, "Chemical Affinity." (Lecture V.)

Mathematical, 22, Albemarle-street, W., 8 p.m.

FRIDAY, JUNE 14...Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting, 9 p.m. Mr. C. V. Boys, "Quartz Fibres."

United Service Inst., Whitehall-yard, 3 p.m. Surgeon G. Fleming. "Forage for Military Purposes." (Part II.)

Astronomical, Burlington-house, W., 8 p.m.

Philological, University College, W.C., 8 p.m. Paper by Mr. I. Gollanez.

Quekett Microscopical Club, University College, W.C., 8 p.m.

SATURDAY, JUNE 15...Royal Institution, Albemarle-street, W., 3 p.m. Prof. W. Knight, "Idealism and Experience in Art and Life." (Lecture II.)

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FRIDAY, JUNE 14, 1889.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CONVERSAZIONE.

The Society's Conversazione is fixed to take place at the South Kensington Museum (by permission of the Lords of the Committee of Council on Education), on Friday, June 28.

Each member will receive a card for himself, which will not be transferable, and a card for a lady. No tickets will be sold.

As the accommodation for coats, &c., is very limited, members will greatly promote the general convenience by not bringing with them more wraps than are absolutely necessary. A special building has been erected to serve as a cloak room, but it is of necessity smaller than the court used in former years for the purpose.

The cards of invitation are now in course of issue.

Proceedings of the Society.

Friday, May 31, 1889; Sir William W. Hunter, K.C.S.I., C.I.E., in the chair.

The Chairman, in introducing Mr. McDougall, said he could not do so better than by reading a letter from Viscount Cross, Secretary of State for India. They were all aware of the important efforts made by Lord Cross with a view to placing the Indian wheat trade on a better footing, and his Lordship would have been present that evening but for the pressure of other engagements. He had sent Mr. McDougall the following letter :—

"India-office,
"29th May, 1889.

"My dear Sir,—I am desired by Lord Cross to express his regret that he is unable to be present on the evening of the 31st to hear your important lecture on the 'Wheats of India.'

"You are aware of the deep and active interest which his Lordship takes in this matter, and of his appreciation of the efforts being made to obtain the wheat from India in a purer state than at present imported.

"Lord Cross has every hope that the discussion recently raised will lead to a modification of the dirt clause in the Indian wheat contract form current in London.--I am, my dear sir, yours very faithfully,

"W. J. Maitland.

"John McDougall, Esq., C.C."

Most of the members present had a general idea of the reforms in the wheat trade, which Mr. McDougall, representing the commerical interests, and Lord Cross, as representing the Government, were endeavouring to effect. They knew that Indian wheat had long been imported into this country in a very impure state, from which arose two great disadvantages. In the first place, Indian wheat fetched a lower price in the English market than it would otherwise do, and, secondly, it was used in smaller quantity. If the difficulty had a necessary connection with the methods of cultivation it might be insuperable, but he believed that the impurities arose mainly not from carelessness on the part of the cultivator but from deliberate adulteration on the part of the first carrier, who was part owner and who brought the wheat to market. The difficulty, therefore, was a trade difficulty, and Mr. McDougall, as one of those most largely interested in the trade, had set himself with zeal and resolution to get rid of it. He could assure Mr. McDougall of two things; first, that the production of wheat in India was practically limited only by the demand for it in this country; and, secondly, that Mr. McDougall would receive, not only from those present but from the members of the Society at large, a hearty welcome in his efforts to bring forward the facts.

The paper read was—

INDIAN WHEATS.

By John McDougall.

The Conference held at the India-office, and presided over by the Right Hon. Viscount Cross, has brought the subject of Indian wheats before not only merchants and millers, who have for some years been familiar with them, but also before the general public, who possibly had no idea that India could supply us with wheat to the considerable extent which our annual imports testify. It is therefore appropriate that this subject should now engage the attention of the Society of Arts. I should have preferred that the honour which has been conferred upon me

in asking me to address you to-night could have been postponed until next session, as I find the subject needs a greater degree of study than I have been able to give it; for when we approach the subject of the vast amount of bread stuff needed for the food of the people of the United Kingdom, and the sources of such supply, we find it demands the consideration of the harvests of the world.

The statistics of the wheat imported into the United Kingdom are available in every necessary detail, but it is very difficult to arrive at a trustworthy estimate of the amount grown in this country. The number of acres sown each year is known, and very careful estimates are made as to the average yield, and in this way a general idea is arrived at, very much depends, however, upon the quality of the wheat when harvested as to the amount available for milling purposes, because a very considerable quantity is consumed on the farms as feeding stuff when the quality is poor, and therefore not of higher value than barley or oats.

We may accept for our purpose to-night the basis arrived at by Messrs. Lawes and Gilbert, that the requirement per head of the population is 5·6 bushels, or exactly 3 cwt. Upon this basis I have prepared tables showing the total quantity of wheat needed each year, and the amount of our imports, then the balance needed must be supplied by our own harvest. The quantities vary very much; the difference will represent the stocks held over from year to year.

For five years (1873-78) the imports of wheat amounted to 55·9 per cent., and the home supply at 44·1 per cent. The imports, however, have largely increased, and in the years 1883-87 stand at 68·9 per cent., as against 31·1 per cent. But perhaps the most remarkable change has been in the great decrease in the supply from Europe (including Egypt), and the large increase in the supplies from British Possessions and America.

Table A1 shows the per-centages of imports from different countries. Table A, the same imports calculated upon per-centages of our total requirements.

It is a matter of grave consideration to a country so thickly populated as ours that we should be dependent upon foreign supply for 70 per cent. of our bread stuff. It is, therefore, most desirable that every effort should be made to encourage the importation of wheat from States with which we are closely in union.

In 1873 we received 1·4 per cent. of our imports from India, whose wheat was little known and was looked upon with much disfavour. Its hard dry condition and the dirt with which it was mixed prevented all but a few millers from having anything to do with it. In 1876-77 there was a considerable increase in the supply, but it again fell very low in 1880-81. It recovered in the following years and the quantity became very considerable, reading, in 1886, as high as 16·7 per cent. The consideration of Indian wheats must necessarily include some general information about India, and, as I have no personal knowledge, I have taken the liberty of quoting from that interesting volume on "India," by Sir J. Strachey.

"India has an area of nearly 1,600,000 square miles, and contains about 258,000,000 of people. Excluding Burma, it may be roughly divided into two regions.

"The first of these is a vast alluvial plain, lying immediately below the Himalayas, and stretching with an unbroken surface for some 1,700 miles across Northern India. Its eastern and central portions are watered by the Ganges and Brahmaputra and their tributaries, the northern and western portions by the river systems of the Indus. At its highest point on the watershed between the feeders of the Indus and the Ganges it is not more than 1,000 feet above the sea. At its eastern end it extends over the delta of the Ganges and Brahmaputra, and includes the greater part of the province of Bengal. At its northern and western extremities it spreads down the Indus to the Arabian Sea, over the Punjab, Rajputana, and Sindh. The central portions of the plain comprise the North-Western Provinces and Oudh.

"The alluvial deposits of which this vast tract is composed are, as General Strachey says, so finely comminuted that it is no exaggeration to say that it is possible to go from the Bay of Bengal up the Ganges, through the Punjab, and down the Indus again to the sea, over a distance of 2,000 miles and more, without finding a pebble, however small.

"The Indo-Gangetic plain comprises the richest, the most fertile, and the most populous, and historically the most famous countries of India. It covers more than 500,000 square miles, an area as large as France, the German and Austrian Empires, and Italy, and it contains 150,000,000 of people.

"The second region of India lies to the south

of the Indo-Gangetic plain, and includes the great triangular peninsula which projects into the Indian Ocean. It has an area of about 1,000,000 square miles, with a population of about 100,000,000. During the winter a large part of Northern India has a climate as cold as that of spring in the south of Europe, and the time between October and April is sufficiently long to bring to maturity many of the chief agricultural products of the temperate zone. During the summer months, on the other hand, the crops are those of the tropics, or of a kind that do not suffer from excessive heat. There is thus in the productions and processes of agriculture a variety of which we have no example in Europe. I am afraid that the belief that the people throughout India generally live upon rice is almost as prevalent in England as ever. There could be no more complete delusion. Rice, in the greater part of India, is a luxury of the comparatively rich. It is grown where the climate is hot and

TABLE A1 AND A.

		Total Imports.	Needed from U.K. Harvest.	Imports. Europe.	Imports. America.	Imports. British Possessions.	Indian portion of British Possessions.
(Table A 1.)	1873	53·5	46·5	21·6	24·5	7·4	·7
Per-centage of imports (Table A.)	....	....	....	40·4	45·6	14·0	1·4
	1874	50·6	49·4	13·7	30·2	6·7	1·1
,,	....	....	....	27·1	59·6	13·3	2·1
	1875	60·4	39·6	25·9	27·8	6·7	1·2
,,	....	....	....	42·9	45·9	11·2	2·1
	1876	52·1	47·9	19·8	23·4	8·9	3·3
,,	....	....	....	38·4	44·5	17·1	6·3
	1877	63·3	36·7	29·2	24·3	9·8	6·0
,,	....	....	....	46·2	38·4	15·4	9·6
	1878	58·5	41·5	19·2	33·1	6·2	1·8
,,	....	....	....	32·9	56·5	10·6	3·0
	1879	70·9	29·1	17·8	44·8	8·3	·8
,,	....	....	....	25·3	63·1	11·6	1·2
	1880	65·9	34·1	9·5	44·5	11·9	3·1
,,	....	....	....	14·5	67·4	18·1	4·7
	1881	68·0	32·0	10·1	44·7	13·2	6·9
,,	....	....	....	14·8	65·8	19·4	10·2
	1882	76·0	24·0	18·2	44·0	13·8	8·0
,,	....	....	....	23·9	57·9	18·2	10·5
	1883	79·1	20·9	23·8	39·8	15·5	10·5
,,	....	....	....	30·2	50·4	19·4	13·3
	1884	61·3	38·7	12·6	33·9	14·8	7·4
,,	....	....	....	20·5	55·5	23·9	12·0
	1885	74·4	25·6	19·3	37·0	18·1	11·1
,,	....	....	....	25·8	49·9	24·3	14·9
	1886	59·6	40·4	8·4	36·8	14·4	10·1
,,	....	....	....	14·1	61·7	24·2	16·7
	1887	70·4	29·6	10·8	46·2	13·5	7·6
,,	....	....	....	15·3	65·5	19·2	10·8

TABLE A_2.

	Total Requirements at 5·6 bushels per head.	Imports.	Per cent.	Balance required from Home Harvest.	Per cent.
	Cwts.	Cwts.		Cwts.	
1873....	96,532,650	51,631,197	53·5	44,901,453	46·5
1874....	97,504,851	49,322,693	50·6	48,181,858	49·4
1875....	98,516,274	59,546,423	60·4	38,969,653	39·6
1876....	99,599,982	51,904,433	52·1	47,695,549	47·9
1877....	100,727,823	63,491,429	63·3	37,236,394	36·7
1878....	101,831,319	59,691,383	58·5	42,139,936	41·5
1879....	102,907,671	73,002,110	70·9	29,905,561	29·1
1880....	103,868,790	68,459,814	65 9	35,408,976	34·1
1881....	104,856,612	71,344,659	68·0	33,511,953	32·0
1882....	105,891,342	80,562,563	76·0	25,328,839	24·0
1883....	106,835,210	84,550,271	79·1	22,284,939	20·9
1884....	107,884,989	66,175,282	61·3	41,709,707	38·7
1885....	108,993,357	81,289,918	74·4	27,703,439	25·6
1886....	110,128,431	65,797,756	59·6	44,330,675	40·4
1887....	111,228,006	78,381,560	70·4	32,846,446	29 6

Average for years 1873-77—Imports, 55·9 per cent.; balance required from home harvest 44·1 per cent.
,, ,, 1883-87— ,, 68·9 ,, ; ,, ,, ,, 31·1 ,,

damp, and where there are ample means of irrigation; it is a valuable crop in a great part of India, but it is only in Lower Bengal, and in parts of Madras and Bombay, in districts where the conditions of soil and climate are suitable to its abundant production, that it forms the ordinary food of the people, or enters to an important extent into the consumption of the poorer classes. Out of the whole population of India it is probable that not more than a fourth part live upon rice.

"The millets and pulses which form the chief food supply of the people flourish throughout the greater part of India. In the damper and more tropical regions they are cultivated in the drier months of the warm winter; in the drier countries, where the winter is comparatively cold, they are the principal crops of the summer.

"In Northern India the agricultural year begins with the periodical rains, which are established towards the end of June. The crops of the cold season are cut in March and April, after which comes a period of about two months, when, owing to the intense heat and drought, agricultural operations are almost at a standstill. Towards the middle or end of June the heat reaches its extremest point.

"As soon as the rain has sufficiently moistened the ground, the fields are ploughed, and summer and autumnal crops are sown; all these are included in the general name of 'kharif.' The most widely cultivated and the most important to the poorer classes, since they furnish to them and to their cattle the principal means of subsistence, are the millets called 'juár' and 'bájra.' In districts where the climate is damp and irrigation easy, rice is extensively grown at this season.

"The rains are over in Northern India towards the end of September, and in the following month the autumnal crops are for the most part cut.

"In October and November, when the excessive heat and moisture have passed away and the cold season has begun, the soil and climate become suitable for the agricultural produce of temperate latitudes, and the winter crops, known under the general name of 'rabi,' are sown. Between November and March it would be difficult to find a more delightful climate for Englishmen than that of Northern India. The nights and mornings are cold, and even at times frosty, and the days pleasantly warm.

"After Christmas there is almost always a short season of moderate rain, which is of much importance to the growing crops.

"The chief agricultural staples of Northern India at this period of the year are wheat and barley. They occupy nearly 60 per cent. of the whole producing area in the North-West Provinces. Wheat from the North-West Pro-

vinces and Punjab has already become an important source of supply to England, and as the means of communication are extended and cheapened, it will, it may be expected, become still more important hereafter. To what extent Indian wheat may ultimately compete on the English market with wheat from America is a question on which I will not speculate, but there is no doubt that India is capable, under favourable conditions of price, of providing a very large and increasing supply.

"Wheat in the Punjab is a still more important crop than in the North-West Provinces. It is also extensively grown in parts of Central India, Bombay, and the Northern Deccan, and in those countries, as well as in Northern India, it forms the chief article of food among the richer classes. Barley is largely consumed by those who cannot afford to eat wheat."

The acreage under wheat may be taken at about 26,000,000 or 27,000,000; it is exceedingly difficult to arrive at a reliable estimate of the yield per acre, the variation being caused by the different conditions of (1st) irrigation, (2nd) flooding, and (3rd) from depending entirely upon rain.

In the Punjab, with 7,000,000 acres, the variations are, say, 20, 11, 7, average 10; North-West Provinces, with 5,000,000 acres, 22, 15, 9, average 13; Bombay, with 3,000,000 acres, 18, 10, 5, average 8; Central Provinces, 4,000,000 acres, 16, 10, 6, average 8; Berar, 1,000,000 acres, 12, 8, 5, average 5. Taking these as an average we may accept 10 bushels or 600 lbs. as the yield per acre, giving a total harvest of about 140,000,000 cwts. Of this I find the average export for the last five years has been 18,729,851 cwts., equal to about 13 per cent. The proportion of American wheat crop exported being about 32 per cent.

The total exports of wheat from India are—

	Cwts.
1883-4	20,956,495
1884-5	15,830,754
1885-6	21,060,519
1886-7	22,263,320
1887-8	13,538,169
	5)93,649,257
Average	18,729,851 cwts.

And the countries to which they were exported are:—

TABLE B.

	In Thousands of Cwts.					
	1883-4.	1884-5.	1885-6.	1886-7.	1887-8.	Average.
United Kingdom	10,508	7,445	12,071	9,667	6,040	9,146
Belgium	2,593	1,738	2,661	2,404	596	1,998
France..........................	3,398	3,312	2,145	2,803	2,559	2,843
Holland	193	134	86	207	60	136
Italy	445	701	1,21[illegible]	5,212	3,074	2,130
Malta	124	93	[illegible]	84	10	69
Spain	107	93	270	184	258	182
Egypt	3,306	2,149	2,296	1,317	660	1,945
Mauritius and Réunion	91	35	34	57	42	51
Aden and Arabia	27	82	174	168	147	119

TABLE C.—Showing the Quantity Exported from each Province.

	1883-4.	1884-5.	1885-6.	1886-7.	1887-8.
	Cwts.	Cwts.	Cwts.	Cwts.	Cwts.
Bombay	8,970,603	8,993,108	10,608,680	12,606,144	8,541,621
Sind	4,372,832	4,271,860	6,241,017	2,613,748	661,758
Bengal	7,611,535	2,563,204	4,189,672	7,037,957	4,334,768
Madras	1,525	1,315	1,872	998	1,005
Burma	—	2,267	19,278	4,473	17
	20,956,495	15,831,754	21,060,519	22,263,320	13,538,169

It will be a matter of interest to see the number of proprietors or tenants, with the size of their holdings. I have put together in a Table the number of proprietors or tenants under nine divisions of different sizes, from under ten acres to over 50,000. In Madras the vast proportion are under 10 acres, those of Bombay under 50 acres, and the North-West Provinces between 50 and under 500 acres, whilst in the Punjab they are principally under 5,000 acres.

TABLE D.—SIZES OF ESTATES AND NUMBER OF PROPRIETORS.

	Under 10 acres.	Under 20 acres.	Under 50 acres.	Under 100 acres.	Under 500 acres.	Under 1,000 acres	Under 5,000 acres.	Under 50,000 acres.	Above 50,000 acres.
Madras	3,955,788	..	740,072	197	..	..	986	118	68
Bombay	..	..	1,284,208	13	24,509	110,865	..	..	..
North - West Provinces....	..	..	..	1,024,480	1,261,844	108,720	2,060	..	..
Oudh	..	..	..	..	14,465	127,906	420	62	43
Punjab..........	..	..	..	..	5,865	54,524	2,763,398	..	..
Central Provinces	..	38,085	..	8,451	6,279	17,667	41,380	..	12
Lower Burma....	625,651	..	..	..	2	3	54	..	26
Assam	142,548	..	49,532	1	361	181	495	..	..
Coorg	11,361	5,643	..	..	..	..	..	..	..
Berar	..	1,469	309,862	..	..	513	..	..	..
	4,735,548	45,197	2,383,674	1,033,142	1,313,825	420,379	2,808,813	180	149

Extract from the Report of the Director of Agriculture in Bombay.

"The greater part of the cultivation is done by the ryot himself and by his regular farm labourers. But even the poorest ryot has to employ hired hands for certain operations, viz. :—1. Hand-weeding; 2. Harvesting—(*a*) reaping, (*b*) binding; 3. Thrashing. The other acts of husbandry are—1. Harrowing; 2. Ploughing; 3. Sowing; 4. Bullock-hoeing.

"*Harrowing.*—In an acre the harrow will make 66 turns of 110 yards each. The bullocks will travel then 7,260 yards. Horses go about two miles an hour in the plough. Bullocks go scarcely a mile an hour, working a bullock power on the flat without stoppages. I should say, therefore, that, taking turnings into consideration, the harrow will not work at a faster rate than half a mile an hour, or four miles in a working day of eight hours. No doubt the harrow frequently overlaps land already gone over. The ryot will thus harrow one acre a day.

"*Sowing.*—Drills 11 inches apart. There will be in the acre supposed above 144 drills of 110 yards ach. The seed-drill forms two drills at each turne. It will make 72 turns in the acre, or the cattle will travel 7,920 yards. Sowing is a careful process. The sower has to feed the seed cup as well as watch the cattle, and has to keep his line correct. It will take at least as long to get over 7,920 yards with the seed-drill as 7,260 yards with the harrow. The acreage sown in a day would, therefore, not be greater than an acre, perhaps less. Cost, therefore, 8 annas per acre, or perhaps 10 annas. The seed-harrow follows the seed-drill. It is wider and lighter of draught. Time might be economised by using it for one-third of the day after the seed-drill has worked two-thirds of the day, but this is not done because of the loss which would be sustained from birds eating the uncovered seed. When a ryot has only two bullocks he sows till noon and covers up the seed in the afternoon.

"*Seed.*—It is very difficult to estimate the amount sown. It varies in different places. Early sowings require less than late. I think 4 maunds for 17 acres, or 45 lbs. per acre is a fair one; but I am convinced that frequently as little as 30 lbs. are used in early sowing. At sowing time beggars prowl about the fields and extort a little from each man. The farmer himself does not know what he sows.

"*Hand-weeding* is a small item in wheat cultivation. The weeders are women paid at the rate of 1½ annas a day. I would put an ordinary cost of 8 annas an acre for each weeding.

"*Harvesting.*—Hired labour. This work is given out on contract, and there appear to be at least two common kinds of contract. One based on the number of sheaves, and the other on the out-turn of grain on the thrashing floor.

"The reapers and binders are often different sets of hands, though generally I think that reaping and binding are contracted for together. The rate varies, but five sheaves per cent. for reaping, and one per cent. for binding, or six per cent for both operations, is the most usual rate. But, be it noted, that the

reapers are always permitted to choose their sheaves, and they naturally pick the best. In an experiment lately made, I found that where the sheaves average 10 lbs., the six best weighed $13\frac{1}{2}$ lbs. a piece, so that the reapers would get 8 instead of 6 per cent. of the crop as it lies in the field. The other system appears more enlightened and fair to both parties generally. It is founded on the amount of seed sown. The reapers and binders are under it entitled to an equivalent of that amount, three to five maunds per acre. The ryot loses if the crop is poor, but the reaper's argument is that a poor crop is as difficult to pull as a good one.

"*Thrashing.*—The farmer carries his own crop home, and if each item is to be estimated at its money cost, the cost of carrying must be included. It is so variable that I won't attempt to lay down any approximation. On the thrashing floor the ryot supplies the bullocks and generally hires the labourers, who beat out the field-earth from the roots, spread the loosened sheaves on the floor, drive the cattle, and then winnow the corn from the chaff. As a rule here they receive 1 out of 21 equal parts of the yield of grain. The chaff all goes to the farmer. If, as is often the case, the thrashing and winnowing are done by two hired hands and two monthly labourers, the former get only half the share above noted."

This description of wheat cultivation in India forms a great contrast to that with which we are familiar in England, or with that carried on in America, with its vast quantity of machinery, but which, on the other hand, is handicapped by the high cost of the labour market. It is likely the two countries may be considered as about equal in the average in these respects, but America has a great advantage in the vast extension of its railway communication through almost every part of the country.

MILES OF RAILWAY.

	United States.	India.
1860	30,635	839
1865	35,085	3,372
1870	52,914	4,775
1875	74,096	6,519
1880	92,147	9,308
1885	127,729	12,375

This great extension of railways enables America to deliver her wheat freely at the port of shipment, whereas in India the cost of long cartage prohibits a large bulk of the crop from being exported.

Grading Samples.—It is remarkable to compare the advance made in America on the commercial side of treating the wheat crop with the old-fashioned ways still retained in India.

A farmer in America, say in the far West, takes his wheat to the railway depôt, where it is received and sent to the nearest elevator. An official samples it as to quality and decides as to its grade. It is then weighed and stored with other wheat of the same grade, and a certificate is issued to the farmer, stating both quantity and quality, and it is with this certificate only that he has then to deal.

In India every little lot of wheat has to be carried by the owner to his market, may be more than once; it then passes from dealer to dealer, each time causing expense and loss; and no two quantities being of the same grade. It will be for the serious consideration of the Government of India, which has so great an interest in the railways, to consider the advisability of providing stores and officials, whose certificates for both quantity and quality would be accepted by the merchants and exporters. Perhaps the difficulty most felt, and which would be the most easily overcome, is the condition in which the Indian wheats are exported.

Indian wheats are divided into sixteen standards, and are known as:—No. 1 club Calcutta, No. 2 club Calcutta, hard Calcutta, soft red Calcutta, choice white Bombay, No. 1 club Bombay, soft red Bombay, hard white Bombay, hard red Bombay, red club Bombay, white Jubbulpore, white Delhi, red Delhi, Atbara (red), white Karachi, red Karachi.

Each class of wheat has its own special value whether it is high or low, but whatever this value may be is decreased by the mixture with any of the other classes. The hard and soft, the white and red, all need different treatment by the miller when he comes to use them to the best advantage in making flour.

This mixture of different kinds of grain, whilst very undesirable, is of much less consequence than the presence of the impurities with which it is adulterated. The dirty condition of Indian wheat is of all others the greatest drawback to its much increased demand.

In the form of contract for the *c.i.f.* purchase of Indian wheat, the quality is stated to be of "fair average quality" (*f.a.q.*). This means that each parcel on arrival is sampled by the Dock Company, then the samples of each class and of each month form the standard, so that it is not the sample of what is grown, but that of what arrives here which forms the standard.

The Commissioner of Settlement and Agriculture in the Punjab has collected reports

from twenty-six districts in this province, which deal very fully with the subject. These reports vary very much. In districts where there is no exportation the growers are indifferent as to mixing grain, but in districts where a larger quantity of wheat is grown and exported considerable care is taken, as in the district of Ludhiana. This is the principal grain mart of the district. It is roughly estimated that (45,00,000) 45 lacs of rupees worth of grain have been exported from here within the last three years. I remember that during the Madras famine in 1878-79, 30 lacs of maunds of grain were calculated to have been exported from this district. The finer wheats can be cultivated on the unirrigated lands, but the great objection to the cultivation of these kinds is, that both in irrigated and unirrigated the produce in grain is about 10 per cent. less than the output of the coarser red wheat.

The cultivator never garners in a dirty state. The wheat is remarkably free from dirt while with the cultivator, and therefore no measures are necessary in that direction.

The dirt is mixed with the grain in the first instance by the cartmen who bring it in, and who are also traders. About 90 per cent. of these men do not bring their own grain. They buy it from the producers, and bring it to Ludhiana on speculation. These men both water it and mix dirt with it.

There are ten or eleven villages in which the lower classes make it a trade to supply different coloured earths to suit the colour and size of the different kinds of grain. The earth is worked into small grains to look like grain, and the traders say it is impossible to winnow out this description of dirt. The cultivators never mix grain when garnering. It is the cartmen or first traders and carriers who do this.

Water, again, is put in to increase weight. All these practices are resorted to by the conveying traders in self-protection against the tricks of the traders, who rob them in various ways.

To remedy the evil of adulteration as above described, the traders and brokers here have amongst themselves, after some days' disputes and discussions, framed the following rules:—

"1. That they will not purchase or export grain mixed with dirt, and in order to ensure clean grain, winnowing machines have been made up to a pattern procured from Calcutta.

"2. The brokerage dues to be limited.

"3. Short weighing or deceit in the matter of current rates to be abandoned."

This is a remarkable scene. Natives, after some days disputing and discussion, arrived at resolutions which the London Corn Trade Association still refuse to adopt. In response to the invitation of Lord Cross to discuss how Indian wheats might be exported in a clean condition, the gentlemen of the East India Committee of that Association adopted a memorandum concluding with this summary:—

"Seeing, therefore, that the natural condition at present of Indian wheats is to contain about 4 per cent. of admixture on the Bombay side, and 5 per cent. on the Calcutta, that under these circumstances it is not practicable to induce the Indian shippers to change their system of purchasing, and instead of buying on the above natural refractions, to introduce an artificial basis of a 2 per cent. refraction; that buyers practically are not prepared to pay a proportionately higher price for cleaner wheats; that the system of selling on analysis here is altogether impracticable and unadvisable; that the conditions of the Indian wheat trade, although slowly, are gradually improving; that India ships and sells all her wheat available for export year by year, and that her development in this branch, at least, is not prevented by the present condition of her wheats; that the interference of Government in questions of contract, as between seller and buyer, is unadvisable. Our opinion is that it is not advisable or desirable to try and force sudden and radical changes in the natural condition of a trade, but that it is preferable to let the improvement come gradually out of the trade itself, taking it for granted that merchants, sellers and buyers, shippers, and consumers, &c., are too keenly alive to their interests to allow any opportunity for improvement in the trade, when such becomes advisable, to pass by."

This opinion is based upon the assumption that it is the "natural condition," of Indian wheats to have 4 or 5 per cent. of admixture.

The discussion, however, clearly showed that this opinion was not shared by the majority of those present. All the representatives from Liverpool and the north of England, and several from the south and west, protested very strongly, and urged the adoption of a new form of contract, limiting all admixture to 2 per cent. I hear that this protest will be carried on by the trade, and I trust may be effectual in bringing a remedy to the present conditions.

It is asserted that millers will not give a higher price for a clean sample of wheat, but this simply means it is impossible to sell an

odd sample on the *c.i.f.* terms. When wheat is offered on the "stand" market, there is no doubt about the increased value of a clean over a dirty sample.

In November, 1888, I analysed one of each of the standard samples of the 1887 crop, and made a report. This report was sent from the India-office to 732 of the principal millers in the United Kingdom, with a request that replies might be made to several questions as to the impurities affecting the use of these wheats:—

348 millers replied that they could only use these wheats in limited quantities because of their impurities.

461 millers replied that they would use much larger quantities if they could obtain them in a clean state.

322 millers state that they buy the earlier shipments at a higher price because of their superior quality.

429 millers express a strong desire to charge the *f.a.q.* form of contract for one limiting the admixture to one not exceeding 2 per cent.

This all goes to show that the demand will in future be for clean Indian wheats, and it is only some few large millers who have erected extensive cleaning machinery, and so are in a position to use even dirty wheats, and the London Corn Trade Association, who stand in the way of this much needed reform.

Flour.—A great development has been given to this industry by the successful working of steam flour mills in Bombay. Not only is there a considerable local demand, but largely increasing quantities are being exported to Aden, Arabia, Persia, Mauritius, Ceylon, and Natal. The quantity exported in 1887 was 322,164 cwts.

Very much of what has been said in reference to wheats will also apply to pulse, oats, barley,

TABLE E.—INDIAN WHEATS IMPORTED FROM CALCUTTA.

Description of Wheat.	Date.	Red.	White.	Admixture.					Weevilled.	Damaged.	Total Loss.
				Dust.	Dirt.	Seeds.	Barley, Oats, or Rye.	Total.			
	1887.										
No. 1 Club Calcutta (White)	May	16·4	80·4	·9	·7	1·4	·2	3·2	·1	·2	3·5
,, ,, ,, ...	June	19·1	77·1	·1	1·4	1·8	·5	3·8	·8	·3	4·9
No. 2 Club Calcutta (White)	March ..	21·3	77·1	·5	—	·6	·5	1·6	—	2·3	3·9
,, ,, ,, ...	April	31·1	66·2	1·1	—	·6	1·0	2·7	—	4·1	6·8
,, ,, ,, ...	May	25·8	71·0	·4	·4	·9	1·5	3·2	·3	1·2	4·7
,, ,, ,, ...	June	35·1	62·0	·8	—	·9	1·2	2·9	—	·9	3·8
,, ,, ,, ...	July	44·8	50·0	1·6	·5	1·9	1·2	5·2	·7	—	5·9
,, ,, ,, ...	August ..	42·8	50·2	3·0	·2	2·2	1·6	7·0	2 0	1·3	10·3
,, ,, ,, ...	September	39·1	56·2	·9	·5	1·7	1·6	4·7	3·5	·6	8·8
,, ,, ,, ...	October ..	37·5	58·0	1·5	·4	2·0	·6	4·5	2·2	·8	7·5
,, ,, ,, ...	November	35·0	59·1	1·7	·8	2·2	1·2	5·9	5·1	1·4	12·4
Hard Calcutta	April	37·8	58·8	·7	1·2	·6	·9	3·4	—	·4	3·8
,, ,, ...	May	41·5	55·0	·8	1·1	·8	·8	3·5	·1	·2	3·8
,, ,, ...	June	39 4	58·4	·3	·4	·8	·7	2·2	·7	·8	3·7
,, ,, ...	October ..	31·2	63·2	3·9	·4	·9	·4	5·6	2·2	·3	8·1
,, ,, ...	November	38·2	53·3	6·6	·6	·9	·4	8·5	4·2	1·4	14·1
,, ,, ...	December	31·1	66·0	·5	·4	·9	1·1	2·9	5·7	1·0	9·5
Soft Red Calcutta	April	93·8	1·8	1·3	1·2	1·1	·8	4·4	—	·4	4·8
,, ,, ...	May	90·5	5·6	·9	·8	1·3	·9	3·9	·2	·6	4·7
,, ,, ...	June	87·7	7·4	1·7	·6	1·1	1·5	4·9	1·3	·8	7·0
,, ,, ...	July	89·9	2·7	4·8	·5	·7	1·4	7·4	·8	—	8·2
,, ,, ...	August ..	90·5	3·8	1·6	·5	1·2	2·4	5·7	3·2	·2	9·1
,, ,, ...	September	91·3	4·2	1·3	·6	1·0	1·6	4·5	3·7	·7	8·9
,, ,, ...	November	88·8	5·1	1·5	·7	1·8	2·1	6·1	6·1	·5	12·7
,, ,, ...	December	91·3	4·8	·8	·8	1·3	1·0	3·9	5·3	·4	9·6

TABLE F.—INDIAN WHEATS IMPORTED FROM BOMBAY AND KARACHI.

Description of Wheat.	Date.	Red.	White.	Admixture. Dust.	Dirt.	Seeds.	Barley, Oats, or Rye.	Total.	Weevilled.	Damaged.	Total Loss.
	1887.										
Choice White Bombay	February	4·5	94·1	·1	1·1	·2	—	1·4	—	·5	1·9
No. 1 Club Bombay (White)	April	10·1	87·2	·7	1·3	·7	—	2·7	·1	·4	3·2
,, ,, ,,	May	11·5	86·4	·4	1·4	·3	—	2·1	—	·2	2·3
,, ,, ,,	June	10·6	86·8	·4	1·8	·4	—	2·6	—	·6	3·2
,, ,, ,,	July	11·6	84·8	1·3	1·4	·9	—	3·6	·5	·7	4·8
,, ,, ,,	August	11·1	86·5	·9	·5	1·0	—	2·4	·5	·4	3·3
,, ,, ,,	September	10·5	87·7	·7	·6	·5	—	1·8	2·4	·8	5·0
,, ,, ,,	October	12·0	85·4	·6	·9	1·1	—	2 6	4·2	·9	7·7
,, ,, ,,	November	12·6	82·9	2·1	1·5	·9	—	4·5	1·4	·4	6·3
,, ,, ,,	December	10·9	86·8	·4	1·1	·8	—	2·3	·7	·6	3·6
Soft Red Bombay	April	97·8	·4	·4	1·4	—	—	1·8	—	—	1·8
,, ,,	May	97·5	·9	·9	·7	—	—	1·6	—	—	1·6
,, ,,	June	96·2	1·5	1·1	1·2	—	—	2·3	—	—	2·3
Hard White Bombay	April	21·1	77·8	·2	·8	·1	—	1·1	—	—	1·1
,, ,,	August	16·8	81·7	·4	1·1	—	—	1·5	·6	—	2·1
Hard Red Bombay	March	97·4	·8	·8	1·0	—	—	1·8	—	·3	2·1
,, ,,	April	96·7	1·7	·4	1·1	·1	—	1·6	—	·6	2·2
,, ,,	July	95·7	1·6	·3	1·9	·5	—	2·7	—	·5	3·2
Red Club Bombay	June	73·2	24·0	·4	1·8	·6	—	2·8	·2	·6	3·6
White Jubbulpore	July	15·0	81·8	·6	1·0	1·6	—	3·2	—	·4	3·6
White Delhi	May	23·2	73·7	·9	·2	·8	1·2	3·1	—	·4	3·5
,, ,,	June	19·0	77·1	1·0	·3	1·1	1·5	3·9	·2	·5	4·6
,, ,,	July	15·9	78·6	·5	1·1	·7	3·2	5·5	·5	·6	6·6
Red Delhi	July	93·4	·9	·9	·7	·6	3·5	5·7	·5	·7	6·9
Atbara (Red)	February	96·8	·6	·6	1·4	·6	—	2·6	3·4	1·9	7·9
,, ,,	March	95·4	1·0	1·5	1·6	·5	—	3·6	—	—	3·6
,, ,,	April	94·8	1·1	2·1	1·5	·5	—	4·1	—	·4	4·5
,, ,,	May	97·0	·3	·5	1·7	·5	—	2·7	—	—	2·7
White Karachi	July	17·1	78·3	·8	·7	·8	2·3	4·6	·3	·7	5·6
,, ,,	October	34·3	58·2	1·2	·4	·8	5·1	7·5	1·7	·6	9·8
,, ,,	December	19·2	70·5	·8	·5	·4	8·6	10·3	1·3	·6	12·2
Red Karachi	July	86·0	6·6	·6	·6	1·0	5·2	7·4	·2	·3	7·9
,, ,,	December	79·4	12·1	·2	·6	—	7·7	8·5	·8	—	9·3

and millet. The trade in these has greatly extended, and with improved condition would come largely into demand. Last year the exports were 1,426,058 cwts., and valued at 35 lakhs of rupees. Seeds also are a very large trade, being about 16,000,000 cwts., and 1,000 lakhs of rupees.

Quite apart from impurities must be considered the very serious damage to wheat in India by the weevil. The reports made by Mr. Cotes, of the Indian Museum, show that this matter has the attention of the Indian Government, but no practical means for the prevention of damage has yet been found.

As to the qualities of Indian wheats, it is perhaps not necessary to go beyond the results arrived at in my report of 1882. The wheats are now much better known, and the knowledge practically confirms the conclusions then arrived at, viz.:—"We pronounce them to be exceedingly useful wheats, in fact, hardly equalled for what is deficient and wanting in the English markets by any other wheats. Their chief characteristics are just those in which the wheats grown in our variable climate are most deficient. Their great dryness and soundness renders them invaluable for admixture with English wheats that are in any

degree out of condition through moisture. Added to their dryness, the thinness of the skins of these wheats, and consequent greatness of the yield of flour, must always place them in the front rank as a 'millers' ' wheat, whenever they are handled with reasonable intelligence and skill."

Such unprecedented yields of flour, as shown by these wheats ranging from 77·46 to 80·52 per cent., against English 65·2 and American spring 72·2, speaks volumes in their favour, and their value is still further increased by another point of merit of almost equal importance, viz., a larger per-centage of bread may be obtained than from any other of the flours included in this review.

Glancing at all the facts here elaborated, it is evident that these afford a larger margin of profit both to the miller and baker than any other. "We venture to record a conviction we have long held—strongly emphasized by the results of these experiment workings—of the measureless importance of the great resources of the Indian empire being developed to the utmost in producing wheat for this country."

These remarks received some criticism on their publication from some of the trade journals in America, as they considered them much too favourable to the Indian wheats, particularly as to the high yields of bread. The American Government caused tests to be made, and I will now quote from the report of the Commissioner of Agriculture, 1884. Report of the chemist:—

"There being considerable doubt as to whether the samples of American wheats of the preceding experiments were representative, a series of baking experiments, with flours of various grades from different parts of the country, have been carried on in our laboratory with the results that are presented.

"The McDougall Brcs. found, and it has been confirmed by us, that upon the dryness of a flour, or upon the amount of water which it is possible to add to the dough, depends chiefly the amount of bread which it will yield.

"In other respects their conclusions are confirmed, that water is the chief conditioning agent, and that the per-centage of gluten has but little effect on the yield."

The prices of wheats in every country have had almost a continuous fall for many years. It is not my purpose to consider the causes, but to call your attention to the fact that Indian wheat has kept somewhat a higher value than other wheats. It is difficult to form a definite comparison, as there is no official list of prices of Indian wheat, including delivery to the United Kingdom, but from private information I have endeavoured to get as near as possible—taking No. 2 Club Calcutta wheat as the standard of value:—

	No. 2 Club Calcutta.		English.	
1877......	50·6 per 492 lbs.	....	56·9 per 480 lbs.	
1878......	46·3 ,,	....	46·5	,,
1879......	50·0 ,,	....	43·10	,,
1880......	45·3 ,,	....	44·5	,,
1881......	45·9 ,,	....	45·4	,,
1882......	43·4 ,,	....	45·1	,,
1883......	39·1 ,,	....	41·7	,,
1884......	32·10 ,,	....	35·8	,,
1885......	33·2 ,,	....	32·10	,,
1886......	31·10 ,,	....	31·0	,,
1887......	33·1 ,,	....	32·6	,,

I have now to express my conviction that there will be a great future for Indian wheats; there need to be considerable improvements in the means of inland transit, and a guiding hand from the governing officials to teach the natives to improve their agriculture, and the preparations for the export markets; but all these will come when the selfish interest of the few are less considered, and the desire of the British and Irish millers can be met by the offer of clean Indian wheats. They have competed on unfavourable terms hitherto, and under better conditions will take a far higher position in the market.

I have to acknowledge the kind facilities offered to me at the India-office, and to mention that the charts on the table (with the samples of wheat) were prepared and kindly lent to me by Mr. Rose, assistant to Sir George Birdwood.

DISCUSSION.

Mr. W. S. SETON-KARR said he had read Mr. McDougall's reports on Indian wheats, and thought them excellent, showing as they did that those wheats possessed exactly the qualities in which English wheats were deficient, owing to the dryness of the climate, which made the skin thinner and the flour drier; and he believed they also possessed more aroma. He understood that millers found a mixture of Indian and English wheats yielded a flour which made most excellent bread. Great stress had been laid, and very properly, on the dirty state in which Indian wheat arrived in this country, and he feared it was not the only staple in which a similar admixture took place. Cotton and other things were constantly adulterated, if not by the cultivator, by the carter or some petty middleman. The Government might very properly offer facilities to merchants, make roads,

railways, and canals, and perhaps impose regulations, but he was not at all certain that the Government ought to be called upon to establish stores and provide sorters for grain. Laws might be made more stringent against adulteration, though it was always difficult to enforce them. It must be remembered that everything in India was on the most gigantic scale, and the ravages from insects, reptiles, &c., were perfectly appalling. He had seen a whole field of the well-known produce called "gram" literally destroyed by insects. There were certain agencies which he thought would always have a great influence on the development of the Indian trade. In the first place, as long as the exchange continued at its present low rate, it was very favourable to the export of wheat, because the Englishman who sent out a few thousand pounds found it converted into a great many more rupees than if they were worth 2s., and could therefore purchase more wheat. It must also be remembered that owing to the dry climate, if the ryot had an abundant harvest and could not get a good price for his wheat, he would bury it, living on some cheaper grain, such as coarse millet; and naturally the supply depended in some degree on the price. They all knew that for the past few years wheat had not paid the English farmer, but if the ryot had a good harvest and freights were low, there would be some increase in the export from India. But it would be unreasonable to expect that the product would be limitless, and that at any moment India could be called upon to supply our deficit. He was very sorry that the province with which he was best acquainted—Bengal—was not represented in the Tables, and it seemed very remarkable that no statistics could be obtained from that large province.

Sir George Birdwood, K.C.I.E., said he had declined to speak when first called upon, but he desired to do so now in order to protest against the charge so often made, and which the previous speaker seemed to countenance, that the Indian cultivator was responsible for the fraudulent adulteration of Indian wheats with other grains and dirt. The cultivator, he maintained, was responsible for only a proportion, which he would limit to about one-half, of the extraneous matters found in Indian wheats, and that half was naturally, and not fraudulently added. It arose out of the conditions of Indian agriculture. In order to make sure of one of his crops succeeding, the cultivator has to sow his fields with a variety of seeds, and particularly for the late crop, sown in June and July, and reaped in October and November, which includes an extraordinary number of cereal and pulse grains, beside sesamum, castor oil, Indian hemp, and cotton. His crops, therefore, are necessarily very much mixed up alike in cultivation and reaping, and threshing, winnowing, and storing. Every cultivator has his separate threshing floor, out in the open fields, a flat patch of ground beaten smooth with the feet, and a little lime or ashes. Here each kind of grain is, indeed, separately threshed out by the treading of oxen; but in winnowing it —which is done from an open basket, by a man or woman standing on a high stool, and lifting the basket high in air, and pouring the grain in heaps round about the threshing floor — the contiguous heaps of the various grains often overlap along their diffused bases. The mixing of the grains is unavoidable under these circumstances, as is the admixture of a certain quantity of earth when they are gathered up from the ground and stored away in large wicker-work baskets, or enormous earthenware jars. Indeed, one of the characteristic and pleasantest sights in the villages of Western India is that of the house-mother of an afternoon, spreading out the grain to be ground early the following morning for the day's consumption, and patiently picking it all over to clear it of the particles of earth and lime to be perchance found in it. When again, on occasion, there is an abounding harvest, and the heaped grain stands high around the threshing floor, and the neighbouring vats well over with sesamum oil, the impatient gratitude of the simple peasantry leads them to bring forth the devoted kid, and sacrifice it on the spot as a thank offering to the living, felt presence of the all bounteous rural gods, old Hanumaut, and Krishna, with his gay *gopis*.* Now and again, after some remarkably fortunate harvest, a temple is raised on the site of the threshing floor.† It is all these and ancient sanctities, bound up with everything that is done in India, so that no act can be done, good or evil, that is not devotional, which make it so difficult to influence or improve upon the immemorial ways and methods of people, social, agricultural, or industrial. Over and over again the speaker had seen a heavy cotton crop grievously injured through the cultivators leaving the ripe fleecy bolls hanging out on the bushes, or scattered on the ground, during some dewy night, in order to attend the festival of the passing phase of the moon. But the proportion of impurities in Indian wheats due to such causes cannot be more than about 2 per cent., and so far from being of fraudulent admixture, should rather be regarded as a precipitate of piety. But any admixture above 2½ per cent. must be attributed to either the grossest neglect or downright dishonesty, and that on the part of middlemen between the cultivators and the shippers to London. The London shippers, however, have the correction of the abuse entirely in their own hands. They know the men they are dealing with, and absolutely command all the sources from which they export to London the superfluously degraded Indian wheats, aptly designated by Messrs. Ralli Brothers, "the 5 per

* "Panaque, Sylvanumque senem, Nymphasque sorores.!" Geo. ii., 494.

† "Hanc olim veteres vitam coluere Sabini;
Hanc Remus et frater; sic fortis Etruria crevit,
Scilicet et rerum facta est pulcherrima Roma.
* * * * * *
Aureus hanc vitam in terris Saturnus agebat."
Geo. ii., 532-8.

cent. stuff." One can understand the London Corn Association being indifferent about the proposed reform, for the gentlemen to whom Mr. McDougall referred as the principal arbitrators on the impure cargoes of Indian wheats delivered in London were for the most part members also of the London Corn Association. Their conservatism was therefore quite natural. But why the importers to London should be so obstinately lukewarm in the matter was inexplicable to the speaker, and he could only put it down to sheer superfluity of "cussedness." One remedy would be the formation of a syndicate for the purpose of establishing a brand of pure wheat, differentiated for Calcutta, Bombay, and Kurrachee. Again, the millers of the United Kingdom might pass a resolution, formally refusing in future to buy "the 5 per cent. stuff" imported into London. The Liverpool Chamber of Commerce also have it in their power, if they would only courageously use it, to force their 2 per cent. standard on the London market. In conclusion, Sir George Birdwood desired, as representing the Indian Section of the Society of Arts, to thank Mr. McDougall for his thoroughly practical and most interesting paper; and to thank Sir William Hunter also for so kindly coming from Oxford to take the chair, and to give the distinction of his ever welcome presence to the occasion.

Mr. MARTIN WOOD thought that perhaps a little too much stress had been laid on the capability of India to supply an unlimited quantity of wheat. It was said that the supply was virtually limited by the demand, and, again, that the supply was dependent on a better price. Now the price depended on several factors other than the mere cost of cultivation, more especially on the cost of carriage to the coast. The distances were very great, and railway traffic was necessarily costly, and the question was how it could be reduced? The great requirement in the case of all bulky produce was cheap water communication wherever it was practicable. He might refer to a very interesting paper read at the Sassoon Institute at Bombay, in 1884, by Mr. Arthur Forde, an experienced engineer, on the extension of railways with reference to the wheat trade. To that paper a diagram was annexed, with maps of India and England on the same scale, and showing that while there were 13,000 miles of railway in England, there were then only 10,000 in the whole of India. This paper was in the library, and would be worth consulting. The point he wished to draw special attention to was the diagram showing the comparatively small extent to which wheat for export is cultivated in India. 3,306 square miles would grow the whole of the wheat exported in 1882-3, of which 1,630 were allotted to districts having their outlet at Bombay, Kurrachee 642, and Calcutta 1,042. The extent of land carriage which wheat would bear, having regard to the railway rates, was also shown, the average being about 800 miles. Of course it was not worth while to carry dirt all that distance. A certain admixture of dirt was inevitable from the method of cultivation and harvesting, but that was comparatively small. It was obvious that much might be done here, either by public opinion or more stringent measures of compulsion. It seemed as if the great corn factors of London were really the chief offenders; and seeing that Liverpool and the other outports were free from certain influences which seemed to have grown up in London, it might be hoped that the natural rivalry of the Liverpool merchants would operate to modify the extraordinary position which the London trade appeared to be taking up. The growth of the flour trade in India was very interesting. He remembered, as if it were yesterday, the first steam flour mill being put up in Bombay, and here again the question was very much one of the cost of steam power. He did not know whether water power was available in any of the wheat districts, but if it were it must be of very considerable importance. The most obvious method of improving the demand for Indian wheat, as in the case of cotton, or any other staple, was to improve the quality; but considering again the great distance and the cost of carriage, it seemed to him on the general question of the development of Indian commerce, that it would be more profitable to cultivate those products, such as fibres and dye stuffs, which contained a larger value in a smaller bulk. Mr. Seton-Karr seemed to think the export of wheat was dependent on the low value of the rupee. It was a very common notion that as gold was much dearer in proportion than silver, it gave a great advantage to those who exported goods from India; but Mr. O'Conor and others had satisfactorily met that view, and shown that though you got more rupees for a sovereign in India, you got less gold for the produce in England, so that it came to much the same thing. No doubt the rate of exchange stimulated exports at first, but things have since found their level. Mr. McDougall had pointed out that in 1873 there was hardly any export of wheat, but it was only in that year the export duty was taken off by Lord Northbrook.

Surgeon-Major PRINGLE said he felt something like Mr. Seton-Karr with respect to Bengal; his own special province, the North-West and Oude, had hardly been alluded to. During the last twenty years of his service he had lived in the wheat garden of India, where he had often seen immense fields of wheat, unmixed with other grain, extending as far as the eye could reach, without any divisions between them as in England. Reference had been already made to the gigantic scale of everything in India, and the more one thought of it the more difficult it was to make it plain to those who had not been there. He had seen the effects of an army of rats utterly ruining a crop, and only stopped by a river; and monkeys and locusts were occasionally equally destructive. The harvesting in the North-West was quite different from the method pursued in Bombay, where it appeared

they pulled up the wheat, and shook the earth out of the roots. In the North-West they had to be more liberal to the ground, and in many places they merely cut the heads off, and then set the field on fire, no doubt with the object partly, and for which it must be very effectual, of destroying an enormous quantity of insects, which would otherwise be dangerous to future crops. What India wanted was a development of light and cheap railways, which would bring the grain cheaply and quickly to the main lines, and release the bullocks for agriculture. He could not understand where all the adulteration came from ; it was certainly a discredit to our name. We talked about the morality and honesty of British commerce, but when Sir George Birdwood gave him the report on the impurities in Indian wheats he blushed for the morality of the whole thing, for he found that it actually laid down that the adulteration had to be brought up to nearly 5 per cent. ! The great difficulty in India was the absence of proper machinery for winnowing, This operation was simply performed by blowing. energetically, no doubt, but spasmodically, and in the intervals the dust fell down with the grain. No native woman would think of taking the grain to grind for flour without first winnowing it again. A simple winnowing machine which would drive the air with a regular draught, would be as simple a plan as possible, and it would be no use attempting to introduce anything which was not simple. He remembered when some very simple machinery for extracting the juice from sugar cane was introduced, it acted very well for a time, but then something got out of order, and it had to be sent a long distance to be set right, and in the interval all operations had to be suspended. Any machine ought to be so simple that native workmen in the larger villages could keep it in order.

The CHAIRMAN said he thought the lesson to be drawn from the discussion was that honesty in the trade was the best policy. He had never heard a paper which more clearly brought out this simple practical truth. India, it was evident, suffered from defective morality in the wheat trade, and various efforts had been made to show who was to blame. First they heard that it was the wicked carter, and then that it was the wicked importer. He could not say who was to blame individually, but taking the different stages through which the wheat passed, he thought certain conclusions could be arrived at. They knew that the cultivator did not wilfully adulterate the wheat. Sir George Birdwood had indeed explained that some amount of adulteration might be " a precipitate of piety," but he could not say that he entirely followed the argument. There was the honest miller here in England, and there was the honest cultivator in India, but somewhere between came in the middleman, who did not seem to be represented that evening, or perhaps they might be told that he was as honest as either. Wherever the blame lay, Indian wheat had got a bad name with regard to purity, and so long as it remained, the consumption would be restricted, and the price depressed. They had heard that some of the native traders were anxious to get rid of this stigma, and had passed resolutions with a view to improving the purity of the article. He was glad to say that the English trader had not been far behind, and he hoped that the conference held under the presidency of Lord Cross, and the interest which the Secretary of State had taken in the matter, would have an important effect on the trade at home. They wanted, if possible, to get rid of the happy family of arbitrators and umpires, who, in one way or another, levied a fee of about nine guineas on nearly every parcel of Indian wheat which came to market. He was very glad to hear that the value of Indian wheat increased in proportion to its purity in so much greater a proportion than its weight decreased. It paid well to send over a good article. Both the Indian producer and the English trader were beginning to discover this, and he understood that Mr. McDougall, as a member both of an eminent firm of millers and of a firm of chemical manufacturers, gave his professional opinion decidedly in support of that view. The question had been mooted—What could be done by the Government ? He was inclined to think that Government could do, and was doing, a good deal. In the first place, it was now throwing open a large wheat-growing area. Mr. Seton-Karr, as an old Bengal civil servant, lamented that there were no crop-statistics from that province. He had often lamented the same thing, but in Bengal, there being a Permanent Settlement, there was no machinery for collecting crop-statistics. The Government, however, was now making a future for Bengal as a wheat exporting, if not as a wheat producing, country. All that fine dry central region of the Western Bengal frontier and Chatisgarh plateaux, which now had no outlet to the sea, was to have a railway straight across it, commencing with Calcutta on the one side and joining the Bombay railway system on the other. Government was also doing something in England. He never remembered a case in which the Secretary of State had shown greater personal interest in a question of Indian commerce than had been shown by Lord Cross in the reform of the Indian wheat trade, and he hoped that his example, and the great labour which Mr. McDougall had devoted to the subject, would bear fruit. He had no fear about the future of Indian wheat, but it would be well for India, in affording trade facilities, to look at what America had done, where they had even greater land distances to contend with. There could be no doubt that as the railway system in India was extended the available wheat areas would enormously increase. He concluded by proposing a vote of thanks to Mr. McDougall.

Mr. McDOUGALL, in reply, said it was true there were no exact statistics with regard to Bengal ; but on

examining the total quantity exported from each province it would be found that Bengal came out very well. The question of impurities might be put in this way. No one was likely to make much effort to produce clean wheat so long as the English merchants said the natural amount of impurity was from 4 to 5 per cent., and all contracts were made out in those terms. Even if it were garnered clean, the native trader had no inducement to take pains to keep it clean. The same difficulty in the case of cotton was got over by the Indian Government passing a fraud Act, which had the desired effect within a few months; and when that Act was repealed a few years ago, he was told by a Mincing-lane merchant that he could tell the repeal of the Act within two months by the quality of the cotton, which again became dirty. He referred to railways, and to the officials having a guiding hand, because he understood that the Government had more control over the railways in India than either in England or America, and therefore, he thought it reasonable that they should have something to say with reference to providing means for receiving the wheat. He had just received a letter from a large firm, who were considering whether they should form a syndicate for clean wheat and introduce a special brand; a meeting would be held on the coming Friday to talk the matter over. Indian wheat had not a bad name, it had a very good name; it only wanted the impurities to be removed, and every miller would be glad to use it. At present, he did not think 80 per cent. of the millers touched it at all, it was almost solely in the hands of a few very large men who had large machinery with power of cleaning it, and it had been remarked to him—why should I take any steps to improve the quality of Indian wheat when it comes cheaper in consequence of being dirty, and I have the means of cleaning it? On the other hand, in many smaller mills, the introduction of machinery for cleaning would mean practically rebuilding them. However, all northern men were looking out for a change, they felt they were being drifted along in a course they did not like, and unless a new contract form could be made very soon, these northern merchants would adopt a standard for themselves.

Miscellaneous.

DISCOVERY OF NEW GOLD FIELDS IN LOWER CALIFORNIA.

Great interest is manifested at the present time all over the Pacific coast, in the new gold fields of Santa Clara, in Lower California, and there is very little abatement in the mining excitement in either Los Angeles, San Diego, and other towns of Southern California, during the last few weeks. People are leaving in large numbers daily from all these places for the scene of operations, whilst Ensenada is said to be nearly deserted. The mines are situated in the mountains, at a distance of between fifty and sixty miles from this latter town, which is a small seaport fifty miles south of the United States and Mexican boundary line. Although only discovered on the 23rd February, there are already between 2,000 and 3,000 persons camped in the Santa Clara valley, in which the new gold field is situated, and fully as many more are now on their way from Southern California and Arizona. The mines are situated at an altitude of 4,500 feet, and the operations are carried on in three gulches. As yet, little is being done except in placer mining, and this is conducted in the most primitive manner. The dirt is very easily handled, and in some instances has given very rich returns. The dry placers continue to furnish the largest nuggets. Old miners say they have never seen such large pieces of gold taken out of the ground. Bed rock is but a few feet down, and when the boulders are reached, the pick and shovel are laid aside, as scratching with knives and horn spoons begins; the dirt is carried out to the water and is panned. At the present time water is plentiful in these gulches. Rockers and other improved machines are scarce. It is not, however, in the placers, that the future of these mines will depend, but rather in the quartz rock, of which three well defined gold-bearing lodes are known to exist; these descend from the mountain in three gulches, in the most northerly of which the richest finds have been made. One of these lodes has been traced on the surface for a distance of 1,400 feet Mining experts look for rich discoveries as soon as the snow disappears from the mountains. The extent of the placers is limited, and at the present rate they must soon be worked out. From all accounts, however, the Santa Clara mines are undoubtedly the richest that have been discovered on the coast since 1849.

Correspondence.

SCIENCE OF VENTILATION AS APPLIED TO THE INTERIOR OF BUILDINGS.

Mr. W. P. Buchan, 21, Renfrew-street, Glasgow writes:—"Mr. Hoey asserts in his paper read on 29th ult., that the air comes in by "imperceptible diffusion" through his fresh air inlets, and referred to experiments made in proof of this, *inter alia*, by passing a lighted match along the top of the inlet grating without the flame being deflected by the current. I see from page 622 that Mr. T. Osborne Smith was rather astonished at this. Now it is well known to any person having proper experience of this that the speed of fresh air coming in by such inlets as those Mr. Hoey has put into the Liberal Club at Glasgow, will depend greatly upon the direction and force of the wind. If Mr. Hoey made his experiments on a calm day, or when his gratings were on the lee side of the building, then so little air might come in as not to deflect the flame of the match. It so happened when I tested the fresh air inlets afterwards at this Liberal Club smoking room

(about 2 p.m.), I found first that the window was partly open, I therefore shut it, and then held a lighted match over the inlet grating when the incoming air blew it out; another lighted match shared the same fate. There were only three persons in the room smoking, but the smell of tobacco smoke was strong, and a good deal of smoke in it. Two of the smokers sat at the south-east corner of the room, away from both the inlets and the outlets. A member of the club suggested that I should go for my anemometer and measure the speed of the incoming air. I did so, when the speed indicated at the window inlet at south end of room was about 60 feet of an average a minute, sometimes spurting up to 100 feet a minute. The fresh air came in more quickly at some parts of the grating than at others. I consider this fresh air inlet far too low—about or less than three feet high—and very dangerous from its position at the window. I consider it to be liable to give rheumatism, &c., to persons sitting near it. The inlet at the other end of the room, which is about six feet high and at back of the sideboard, I think much more sensible. As to the outlet here into the chimney, it seems to me to be simply that marked "C.," in Fig. 297F, in the fourth edition of my book on "Plumbing and House Drainage," published in 1883, and I showed the bend rounded, as Mr. Hoey recommends, and I also spoke of curtailing the smoke outlet, in order to make the air flue work better, so that I am glad my plan works so well at the Liberal Club. In reference to the Stock Exchange, Glasgow, Mr. Hoey says it is "a palatial structure of ornate style without and within." Yet upon the roof of this "palatial" building and above the ridge he desires a very large old-wife moveable ventilator, more than three feet in diameter, to be placed as the cover of the outlet ventilating tube. The idea is monstrous. If the present mere umbrella is done away with, a proper induced current fixed ventilator ought to be put up, and all the better if of ornamental design to suit the building. This might enable the new gas furnace fitted up in the outlet ventilating tube to be often unlighted, and so keep down the gas bill. The notion of sticking up a big old-wife ventilator upon a palatial building may suit the idea that ventilation is neither an art nor a problem in architecture, but we have got enough of ventilating ugliosities stuck up upon public buildings in Glasgow already, where better taste might have been expected, without adding another to the list. From what was said by the Chairman and Mr. E. C. Robins, as published on pp. 619-20, it would appear that the dado plan of inlet, now claimed as a novelty by Mr. Hoey, had been previously fitted up in the Society of Arts room. As to Mr. Hoey's £50 challenge, a party referred to a building in Port-Glasgow. I might have pointed to a public building satisfactorily ventilated, as recommended by me, in 1886, but the challenge was made to Mr. David Thomson, F.R.I.B.A., Glasgow, so on that account I held back, although I would have been able to say that in this and other cases I had satisfied those concerned without any *continuous outlay* for either gas or anything else, as Mr. Hoey requires.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, JUNE 17...British Architects, 9, Conduit-street, W., 8 p.m.

Asiatic, 22, Albemarle-street, W., 4 p.m.

TUESDAY, JUNE 18...Zoological, 11, Hanover-square, W., 8½ p.m. 1. Prof. Henry H. Giglioli, "A supposed New Genus and Species of Pelagic Gadoids from the Mediterranean." 2. Lieut.-Col. H. H. Godwin-Austen, "A Collection of Land Shells made in Borneo by Mr. A. Everitt, with Descriptions of supposed New Species." 3. Capt. G. E. Shelley, "List of Birds collected by Mr. H. C. V. Hunter in Masai-land." 4. Mr. P. L. Sclater, "Description of Hunter's Antelope."

Colonial Institute, Whitehall-rooms, Hôtel Métropole, Whitehall-place, S.W., 8 p.m. Sir Lepel Griffin, "The Native Princes of India, and their relations with the British Government."

WEDNESDAY, JUNE 19...Meteorological, 25, Great George-street, S.W., 7 p.m. 1. Mr. Robert H. Scott, "The Climate of British North Borneo." 2. Mr. William Ellis, "The Variation of the Temperature of the Air in England during the period 1849 to 1888." 3. Mr. Charles Harding, "Atlantic Weather and Rapid Steamship Navigation." 4. Mr. Henry Corder, "Meteorological Phenomena observed during 1875-87 in the neighbourhood of Chelmsford." 5. Dr. W. Doberck, "Rainfall in China, and Meteorological Observations made at Ichang and South Cape in 1888."

Geological, Burlington-house, W., 8 p.m. 1. Mr. Frank Rutley, "Tachylyte from Victoria-park, Whiteinch, near Glasgow." 2. Mr. S. S. Buckman, "The Descent of *Sonninia* and of *Hammatoceras*." 3. Mr. H. G. Lyons, "Notes on the Bagshot Beds and their Stratigraphy." 4. Miss Jane Donald, "Description of some New Species of Carboniferous Gasteropoda." 5. Mr. J. W. Gregory, "*Cystechinus crassus*, a new species from the Radiolarian Marls of Barbadoes, and the evidence it affords as to the Age and Origin of those Deposits."

Cymmrodorion, 27, Chancery-lane, W.C., 8 p.m. Annual Meeting.

Botanic, Inner Circle, Regent's-park, 2 p.m. Summer Exhibition.

United Service Institute, Whitehall-yard, S.W., 3 p.m. Mr. James Rigg, "The Mechanical Coaling of Steamers."

THURSDAY, JUNE 20...Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

Linnean, Burlington-house, W., 8 p.m. 1. Dr. John Anderson, "The Mammals, Reptiles, and Batrachia of the Mergui Archipelago." 2. Mr. Charles Parke, "The Prolonged Vitality in a Fritillary Bulb."

Chemical, Burlington-house, W., 8 p.m.

Historical, 11, Chandos-street, W., 8½ p.m.

Numismatic, 4, St. Martin's-place, W.C., 7 p.m. Annual Meeting.

FRIDAY, JUNE 21...Sanitary Institute, 74A, Margaret-street, W., 5 p.m. Mr. R. B. Carter, "Some Considerations on Ocular Hygiene."

Philological, University College, W.C., 8 p.m. Prof. Terrien de La Couperie, "The Chinese Kuwen."

SATURDAY, JUNE 22...Physical, Science Schools, South Kensington, S.W., 3 p.m. Dr. Edward Von Aubel, "Researches on the Electrical Resistance of Bismuth."

Journal of the Society of Arts.

No. 1,909. Vol. XXXVII.

FRIDAY, JUNE 21, 1889.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

FINANCIAL STATEMENT.

The following statement is published in this week's *Journal*, in accordance with sec. 40 of the Society's Bye-laws:—

TREASURERS' STATEMENT OF RECEIPTS, PAYMENTS, AND EXPENDITURE FOR THE YEAR ENDING MAY 31ST, 1889.

Dr.

	£	s.	d.	£	s.	d.
To Cash in hands of Messrs. Coutts and Co., 31st May, 1888... ...	1,308	14	0			
Do in hands of Secretary...	18	6	8			
				1,327	0	8
,, Subscriptions received during the year from Members and Institutions in Union	6 023	8	0			
Life Compositions	273	0	0			
				6,296	8	0
.. Dividends and Interest				790	0	5
.. Ground Rents				174	15	0
.. Examination Fees...				311	13	0
.. Advertisements				923	1	9
.. Balance of grant from Foreign-office for promoting the Barcelona Exhibition ...				34	14	5
.. Proceeds of transfer of Oude and Rohilkund Railway Stock to Indian Government ...				2,695	11	3
.. Donation from the Goldsmiths' Company towards Art-workmanship Prizes				50	0	0
.. Balance of Entrance Fees for Prime Motors Competition				35	0	0
.. Sales, &c. :—						
Cantor Lectures	21	1	0			
Examination Papers	2	10	2			
Fees for use of meeting-room	39	18	0			
Journal	143	10	0			
Spoiled Post-cards...	2	15	10			
Reports on Prime Motors Competition	12	4	10			
Reports on Canal Conference	18	6	10			
				240	7	5
				£12,879	0	11

Cr.

	£	s.	d.	£	s.	d.
By House:—						
Rent, Rates, and Taxes ...	360	17	0			
Insurance, Gas, Coal, House expenses, and charges incidental to meetings	240	3	4			
Repairs and Alterations ...	142	16	2			
				743	16	6
,, Office:—						
Salaries and Wages	2,046	2	11			
Stationery, Office Printing, and Lithography...	264	16	9			
Advertising	64	13	10			
Postage Stamps, Messengers' Fares, and Parcels	198	12	2			
				2,574	5	8
,, Library, Bookbinding, &c...				86	8	7
,, Conversazione (1888)				407	5	6
,, *Journal*, including Printing, Stamps, and Distribution				2,247	7	8
,, Advertisements (Agents and Printing) ...				438	18	4
,, Examinations				387	7	1
,, Medals:—						
Albert	23	9	6			
Society's	25	10	0			
Co-operative Exhibition ...	12	19	0			
				61	18	6
,, Swiney Prize				200	0	0
,, Owen Jones Prizes				28	1	0
, Cantor Lectures				267	5	10
,, Memorial Tablets				7	4	6
,, Juvenile Lectures...				20	10	0
,, Sections:—						
Applied Art	61	16	0			
Foreign and Colonial	61	8	0			
Indian...	61	4	0			
				184	8	0
,, Barcelona Exhibition, advertising, &c... ...				70	18	0
,, Committees:—						
Art Workmanship	15	0	0			
General Expenses	14	18	4			
				29	18	4
,, Prime Motors Competition				683	0	5
,, Canal Conference				54	19	11
,, Balance of Grant returned to Goldsmiths' Company (Art Workmanship prize)				45	0	0
,, Investments:—						
Consols (Life Compositions of the year)	273	0	0			
Purchase of Ground Rents (including sum paid off by Oude and Rohilkund Railway Company)	3.175	3	1			
				3,448	3	1
				11,986	16	11
,, Cash in hands of Messrs Coutts and Co., May 31st, 1889... ...	875	2	10			
Do. in hands of Secretary ...	17	1	2			
				892	4	0
				£12,879	0	11

Liabilities.	£ s. d.	£ s. d.
To Accounts due...	372 16 6	
,, Rates	56 5 0	
,, Examiners' Fees	189 12 0	
,, Sections:—Applied Art, Foreign and Colonial, and Indian	180 0 0	
,, Accumulations under Trusts	249 5 9	
,, Art Workmanship Prizes	190 0 0	
		1,237 19 3
Excess of Assets over Liabilities		15,861 0 1
		£17,098 19 4

Assets.	£ s. d.	£ s. d.
By Society's Funds invested in—		
£7,823 12s. 8d. Consols, worth on 31st May, 1889	7,755 3 10	
£500 Canada 4 per Cent. Stock, worth on the 31st May, 1889	560 0 0	
£500 South Australia 4 per Cent. Stock, worth on 31st May, 1889	552 10 0	
£530 10s. 1d. New South Wales 3½ per Cent. Stock, worth on 31st May, 1889	559 13 8	
£217 Great Indian Peninsula Railway 4 per Cent. Debenture Stock, worth on 31st May, 1889	264 14 10	
£1,500 Queensland 4 per Cent. Bonds, worth on 31st May, 1889	1,605 0 0	
£500 Natal 4 per Cent. Stock, worth on 31st May, 1889	560 0 0	
Ground Rents	526 18 9	
		12,384 1 1
,, Subscriptions of the year uncollected	582 4 0	
,, Arrears, estimated as recoverable	200 0 0	
		782 4 0
,, Property of the Society, including Barry's Pictures and Lease of House		2,000 0 0
,, Advertisements on the Books, due and in course of execution*		740 10 3
,, Cash in hands of Messrs. Coutts and Co., 31st May, 1889		875 2 10
,, Do. on Deposit (including interest on Trusts)		300 0 0
,, Do. in hands of Secretary		17 1 2
		£17,098 19 4

* A portion of this sum is subject to charges for printing.

Investments &c., Standing in the Name of the Society.

Ground Rents	£7,690 0 0
Consols	9,394 18 8
Metropolitan Railway 4 per Cent. Perpetual Preference Stock	500 0 0
Bombay and Baroda Railway 5 per Cent. Guaranteed Stock	2,450 0 0
Canada 4 per Cent. Stock	923 0 0
South Australia 4 per Cent. Stock	605 16 0
New South Wales 3½ per Cent. Stock	530 10 1
Great Indian Peninsula Railway 4 per Cent. Guaranteed Debenture Stock	2,170 0 0
Queensland 4 per Cent. Bonds	1,500 0 0
Natal 4 per Cent. Stock	500 0 0
Cash on Deposit with Messrs. Coutts and Co.	300 0 0

Trust Funds included in the Above.

1. Dr. Swiney's Bequest	£4,500 0 0	Invested in ground-rents, and chargeable with a sum of £200 once in five years.
2. John Stock Trust	100 0 0	Consols, chargeable with the Award of a Medal.
3. Benjamin Shaw Trust for Industrial Hygiène Prize	133 6 8	,, ,, ,, Interest as a Money Prize.
4. North London Exhibition Trust	192 2 1	,, ,, ,, ,, ,,
5. Fothergill Trust	388 1 4	,, chargeable with the Award of a Medal.
6. J. Murray, in aid of a Building Fund	54 18 0	,,
7. Subscription to an Endowment Fund	562 2 2	,,
8. Dr. Aldred's Bequest	140 15 9	,, chargeable with the Award of a Prize.
9. Thomas Howard's Bequest	500 0 0	Metropolitan Railway 4 per Cent. Perpetual Preference Stock, chargeable with the Award of a Prize for an Essay.
10. Dr. Cantor's Bequest	4,600 0 0	Bombay and Baroda Railway Stock, and Ground-rents Interest applied to the Cantor Lectures.
11. Owen Jones Memorial Trust	423 0 0	Canada 4 per Cent. Stock, charged with the Award of Prizes to Art Students.
12. Mulready Trust	105 16 0	South Australia 4 per Cent. Stock, the Interest to be applied to keeping Monument in repair and occasional Prizes to Art Students.
13. Alfred Davis's Bequest	1,953 0 0	Great Indian Peninsula Railway 4 per Cent. Guaranteed Debenture Stock. Interest at the disposal of the Council for promoting the objects of the Society.
14. Accumulated Interest on Trust Funds	249 5 9	On Deposit with Messrs. Coutts and Co.

The Assets, represented by Stock at the Bank of England, and securities, cash on deposit, and cash balance in hands of Messrs. Coutts and Co., as above set forth, have been duly verified.

B. Francis Cobb, } *Treasurers.*
Owen Roberts, }

H. Trueman Wood, *Secretary.*

J. Oldfield Chadwick, F.C.A., *Auditor.*

Society's House, Adelphi, 13th June, 1889.

ANNUAL GENERAL MEETING.

The Council hereby give notice that the One Hundred and Thirty-fifth Annual General Meeting, for the purpose of receiving the Council's Report and the Treasurers' statement of receipts, payments, and expenditure during the past year, and also for the election of officers and new members, will be held, in accordance with the Bye-laws, on Wednesday, the 26th June, at 4 p.m.

(By order of the Council)
H. TRUEMAN WOOD,
Secretary.

CONVERSAZIONE.

The Society's *Conversazione* will take place at the South Kensington Museum (by permission of the Lords of Committee of Council on Education), on Friday, 28th of June.

Promenade Concerts will be given by the Band of the Royal Artillery in the North Court, and by the Band of the Scots Guards (weather permitting) in the Quadrangle of the Museum.

A selection of glees, madrigals, and part-songs will be given by Mr. Edward Plater's Glee Union, in the Lecture Theatre, commencing at 9 o'clock.

The galleries containing the Raphael Cartoons, the Sheepshanks Collection, the Wm. Smith Collection of Water-colour Drawings, the Dyce and Forster Pictures, and the Chantrey Bequest will be open.

The Courts and Corridors of the Ground Floors will be open. The Reception will be held at 8.30 o'clock in the West Architectural Court by the Duke of Abercorn, C.B., Chairman, and other Members of the Council.

As the accommodation for coats, &c., is very limited, members will greatly promote the general convenience by not bringing with them more wraps than are absolutely necessary. A special building has been erected to serve as a cloak room, but it is of necessity smaller than the court used in former years for the purpose.

MEDALS.

The Council have awarded the Society's Silver Medal to the following readers of papers during the Session 1888-9:—

To W. H. DEERING, F.C.S., for his paper on "Explosives."

To W. J. DIBDIN, F.I.C., F.C.S., for his paper on "Standards of Light."

To CONRAD BECK, for his paper on "The Construction of Photographic Lenses."

To Prof. SILVANUS P. THOMPSON, for his paper on "Arc Lamps and their Mechanism."

To Prof. A. B. W. KENNEDY, F.R.S., for his paper on "Objects and Methods of the Society of Arts' Motor Trials."

To GEORGE CLULOW, for his paper on the "Origin and Manufacture of Playing Cards."

To Capt. WIGGINS, F.R.G.S., for his paper on "The Northern Waterway to Siberia."

To Major.-Gen. Sir R. MURDOCH SMITH, K.C.M.G., for his paper on "The Karún as a Trade Route."

To JOHN MCDOUGALL, for his paper on "Indian Wheats."

To Sir JAMES D. LINTON, P.R.I., for his paper on "Some Recent Movements in Relation to the Applied Arts."

To H. H. STATHAM, for his paper on "Architecture in Relation to Landscape."

Thanks were voted to the following Members of the Council for the papers read by them:—

To BENJAMIN BAKER, M.Inst.C.E., for his paper on "The Forth Bridge."

To WILLIAM ANDERSON, M.Inst.C.E., for his paper on "Aluminium and its Manufacture on the Deville-Castner Process."

To Sir JULAND DANVERS, K.C.S.I., for his paper on "The Progress of Railways and Trade of India."

ALBERT MEDAL.

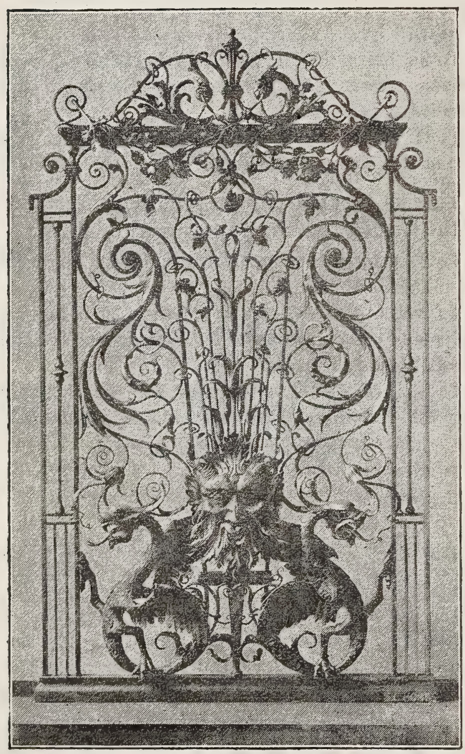
The Council of the Society of Arts have (with the approval of the President, H.R.H. the Prince of Wales) awarded the Albert Medal to John Percy, M.D., F.R.S., "in recognition of his achievements in promoting the Arts, Manufactures, and Commerce, through the world-wide influence which his researches and writings have had upon the progress of the science and practice of metallurgy."

Miscellaneous.

WROUGHT IRON GRILLES.

Twice in our history blacksmithing, as a fine art, has flourished for a time, and then for long periods has lain dormant. At no time did it appear so moribund, however, as in the first decades of the 19th century. Its revival commenced with that of pointed architecture under Pugin and Scott, and was

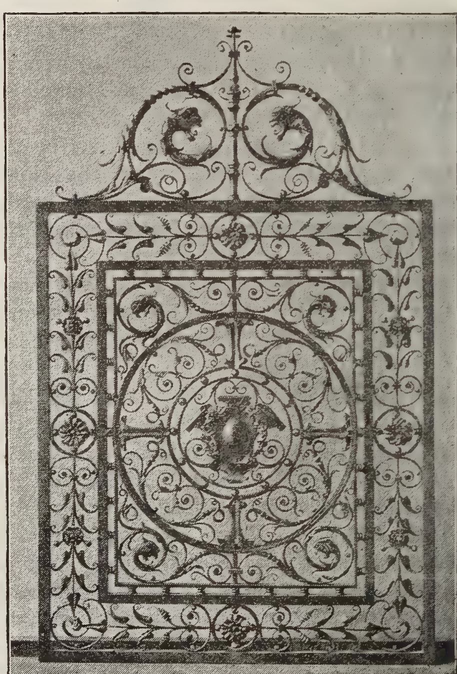
stimulated by Ruskin but in a general way, it has lagged behind its fellow crafts. But the situation has changed within the last half-dozen years, and we now run more risk of a redundant than of too stinted a production, for there is at present a fashion for wrought iron, and it is applied to all kinds of objects hitherto made of brass or bronze. If this fashion is to be more than a passing wave, the smith and his designer must learn to distinguish what is original and good from what is mere vagary. Above all, with such a facile and easily abused material, he should learn to exercise restraint. The movement has been too rapid for thoughtful men or schools to develop, and no educated class of smiths as yet exist, and thus no craft is more in need of help and precept.



First Prize awarded to S. C. Hobbs.

Of all objects in use, none rivals in utility the iron grille, whether used for protection or only for decorative effect. Nothing is less likely to be displaced by change of fashion, for iron affords in proportion to its bulk greater resisting power, and therefore more complete protection, than any other substance. Properly fixed window guards give more security than shutters, and we are no longer confined, as we have been for almost half a century to mere, bars. Elegant forms can be produced, within the reach of every one, and we can interpose between the window and the street beautiful objects which serve [to screen our interiors from observation by day, and to protect them by night.

The use of window guards seem to have been known from the time of Solomon. The oldest actual specimens extant are those recovered in Pompeii, consisting of plain bars exactly like those still used in London areas, though we know that in Rome they were also of scale and lattice designs. Varied designs were used in Byzantine architecture, particularly by the Roman Gauls. The English were unsurpassed as smiths, and some beautiful specimens of grille work tongs from the anvil while the iron was hot; while the mediæval Flemish work which superseded them was more the production of the file, saw, and drill acting on iron cold. We have few specimens of window-grilles in this country, though



Second Prize awarded to William Hooks.

as early as Henry III. all the windows of the numerous palaces were thus protected, but in France a good many are yet extant. Great use was made of them in Italy and Germany, and exquisite specimens, both of Mediæval and Renaissance periods, are preserved in our National Museum at South Kensington. work, Spain of the 16th century far excelled But in these, as in all other specimens of iron-every nation. Spanish window-guards are *chefs-d'œuvre*, simple and dignified in design, yet with refined and elaborate detail, light of aspect, yet of massive strength, furnishing endless designs which deserve our most careful study, though to reproduce

them with the same chiselled and embossed delicacy of detail would cost more time than any smith would prudently spend. The distinguishing character of Spanish grille-work is that the body of the design is full of repose, while the scrolly ornament is concentrated where it least impedes the vision. In the revival of blacksmith's work that followed the Restoration of Charles II.—in consequence, it must be owned, of his partiality for the French fashions of Louis XIV., who encouraged blacksmithing in France with his wonted magnificence—window grilles were only occasionally used, but some most exquisite specimens by a French smith can be

THIRD PRIZE AWARDED TO HENRY ROSS.

seen in St. Paul's Cathedral. Examples are met with here and there as late as the time of the brothers Adam when they were commonly inserted in the fan-lights of street doors and on staircase windows.

In offering prizes for window grilles, the Council of the Society of Arts were desirous of obtaining objects that could be utilised, but which must almost of necessity have been made expressly for the competition. Window-grilles of limited size seemed to meet these requirements, and also to admit of being judged with an approach to precision. The result brought out an amount of technical talent of a surprisingly high order, though the designs themselves erred much on the side of over-elaboration. With proper care and training there can hardly be a doubt but that English smithing is destined once more to take the highest rank.

The three grilles which obtained prizes in the Art Competition are here re-produced.

THE VEGETABLE PRODUCTS OF COLOMBIA.

A report on the agricultural condition of Colombia has recently been published by the Foreign-office, and contains much information on the vegetable resources of that country. The following notes are gathered from it. Besides well-known and established products, such as the cocoanut, cacao, cotton, indigo, sugar-cane, &c., vanilla and Tonquin beans have been tried with fair success; a little tea has also been grown, while nutmegs, cinnamon, and black pepper have been recommended for growth on a large scale in the Magdalena Valley, which is said to be admirably suited for them; but both the capital and the enterprise required for the successful introduction of new products are wanting in Colombia.

Under the head of tobacco, it is stated that these are the four districts of Colombia, each very limited in extent, where tobacco is grown on a large scale—the Magdalena Valley, south of Honda, including Ambalma, Penaliza, and Espinas, which three places supply most of the tobacco used in Bogota and in the interior of the country; Palmyra, in the valley of the Cauca; Giron, in the department of Santander; and Cannen, in the department of Bolivar. The latter district produces more than all the rest together, but the greatest part of its produce, which is of an inferior quality, is exported wholly to Bremen and Hamburg. Tobacco is, however, grown universally on a small scale all over the country, wherever, in fact, the climate does not render it practically impossible. Most farmers and cottagers in the warmer climates have a small plot of it, and dry and cut the leaves themselves, and make their own cigars. This, however, does not apply to the chief tobacco districts, where it does not pay so well to grow it on a small scale, and when, in case it is so grown, it is more advantageous to sell the crop at once to a large manufacturer. Tobacco thrives best in Colombia at a temperature of from 75° to 85°. No great care is taken as to the quality of the soil, though the general opinion seems to be that a sandy soil suits it best, and its cultivation is carried on in a desultory and unscientific manner, quantity being much more thought of than quality. It is partly owing to this, and partly also to various diseases which have attacked the crops of late years, and which have not been studied or understood, but still more owing to the competition of new tobacco-producing countries, that the export trade of Colombia has dwindled so

greatly, and that the export of the superior tobacco of Ambalema, which was formerly one of the chief sources of wealth to the country, has practically collapsed altogether.

In the Magdalena Valley tobacco is planted twice a year; in September, as soon as the rainy season sets in, for the chief crop of the year, and in February for the second crop. It is not the custom, as in some other countries, to cut and dry the whole plant at once, but the leaves are picked off as they ripen, beginning some two months after planting, and continuing in some cases for nearly the whole year. Before the plant flowers a portion of the top is cut off, and then new shoots spring up from the roots, of which all but one are destroyed. This one is left to form a new plant, and in very good land three succesive shoots will grow and produce crops in the year. In this way a plant will give a larger quantity of tobacco in the year than in most tobacco-growing countries. The plants are almost always grown from seed raised on the same plantation, few experiments being made with seeds from other districts or other countries. No manure is used, and the same land is used over and over again for an indefinite number of years. In some districts where disease has exterminated the tobacco plantations, it has been found that for a few years plants grown from seed brought from another district are not attacked, but that ultimately they also are destroyed. By constantly importing fresh seed this might perhaps be avoided, but the experiment was tried on some of the finest tobacco land in Colombia, and it was found that, as the produce of the seed brought from inferior districts began gradually to improve by transportation to the better soil, it became more and more liable to disease, whilst plants grown from seeds brought from districts producing a fine quality of tobacco were attacked at once.

The leaves when picked are hung up to dry in the shade under cover for some twenty days, then put out at night to get slightly damp with the dew, and then packed up in bundles of 12 lb. weight, and left to ferment. They are then made into cigars without any further or artificial process of curing. Pipe tobacco is not made or used in Colombia. Cigarettes, which are very extensively smoked, are imported from Havana, or are made in Colombia from imported tobacco.

Indigo.

The cultivation of this plant was commenced in the valley of the Magdalena some 25 or 30 years ago, and its cultivation rose to be a very important industry for a short time; but it was found that it could not compete in quality with that from India, and most of the plantations were abandoned. The collapse of the trade caused the ruin of numerous planters, who had spent large sums in putting up works for its preparation. Now only a few plantations exist, but there are planters who are still convinced of the suitability of the soil and climate of the Magdalena Valley for its production, and, believing that it failed before owing to bad cultivation and careless preparation, are proposing to plant it again upon a large scale.

Cacao (Theobroma Cacao).

This is one of the most important articles of production in Colombia. It is in daily use in every household, rich and poor, in every district of the country, to quite as great an extent as tea is in England. The departments of Tolima and Cunca produce the greatest quantity, but it is more or less grown in every part of the hot country. It is mostly planted on newly disforested land, on the slopes of the mountains, at an elevation of from 1,000 to 3,500 feet. The variety chiefly grown in Colombia is different from that of Venezuela, which produces the Caracas cocoa, the pods being much larger and containing a greater number of beans; but as the number of pods produced by a single tree is smaller, it is probable that on the whole the Venezuelan variety is the more productive of the two. The quality of the Colombia cacao is little, if at all, inferior to that of the Venezuelan, but is little known in commerce, as only an insignificant amount is exported, the supply scarcely satisfying the demand of the country. It is cultivated in much the same way as in Venezuela, though perhaps less care is taken to keep the plantations in order. It is a crop that requires constant care and labour to weed and clean the ground, and free the trees from the numerous insects, especially caterpillars, which infest them. A most destructive disease has lately attacked the cacao trees in the south of Tolima, which is one of the richest districts of Colombia. One plantation of 12,000 trees near Chaparal, produced only 175 lb. of cacao in 1887, instead of some 18,000 lb., which at $1\frac{1}{2}$ lb. a tree would be a fair average crop. These trees were sixteen years old, and therefore in their prime; some cacao trees, if healthy, bear for a period of from 60 to 80 years. No investigations seems to have been made into the nature of this disease, and no remedy has been suggested. Meanwhile the cacao industry over a large portion of the most productive district of the country seems to be threatened with extinction. The cacao tree begins to bear in three and a half years in the hottest districts, and in five years at an altitude of 3,500 feet. It is carefully shaded for the first year, plantains, or more rarely sugar-cane being planted for the purpose. Trees are also planted which as they grow up give permanent shade to the plantations. A species of Erythrina is most commonly used for this purpose, on account of its rapid growth. Cacao is one of the most, perhaps the most paying crop grown in the country when once it is established; but the initial cost of planting it and keeping the plantations in good order for the first four or five years deters many people from growing it. As compared with coffee, a plantation of cacao of a given number of trees costs nearly twice as much

to establish, but once in full bearing it has the great advantage that no machinery and very little labour is required for preparing the beans for the market, so that the profits are much greater. If land, however, were not so cheap as it is in most of the cacao districts, coffee would have a great advantage, since four times as many coffee trees can be planted to the acre as cacao trees, and the value of the produce of a given number of cacao trees is only from two to two and a half as great as that of the same number of trees, but as the value of land is merely nominal cacao is the more profitable crop of the two.

Sugar-cane.

This, next to maize, is the most extensively cultivated crop in Colombia. It is more grown for making sugar than for its use as the basis of the principal drinks of the country. A large quantity is employed for making aguardiente, or raw spirits, the chief drink of the hot country, and rum. Still more is used for making chicha, the chief drink of the cold country. It is made of molasses, or coarse unrefined sugar, fermented in water, with a large proportion of ground maize. As usually sold it is not more intoxicating than lager beer, as the large quantity of maize checks the fermentation; but if less maize is added, and the fermentation carried on farther, it is extremely intoxicating. It is also very nourishing, and serves as food as well as drink to the majority of the labourers of the cold country. The amount of solid food some of them take is amazingly small in comparison to the chicha they drink.

Sugar-cane ripens in one year in the hot country, and in a year and a half or more in the temperate country. The method of extracting the juice in common use is very primitive and wasteful. The mills are usually rude contrivances, with wooden rollers, worked by mule or ox power; a few only have iron rollers, and anything like complete machinery is unknown. There are two ironworks in the neighbourhood of Bogota, which make simple machines with iron rollers, to be worked by mule power, but the cheapest are beyond the means of most of the small sugar growers.

Rice.

The rice grown in Colombia—or nearly all—of the variety known as hill rice, which can be cultivated on comparatively dry land, and without irrigation. The grain is small, flat, and elongated. Very primitive methods are employed in its cultivation in some parts of the country, the llanos especially. The space to be sown, which may be an acre or two, is fenced in; a head of cattle is driven in after the first rains, and left there for some days to tread up the ground and destroy the grasses, and the rice is then sown broadcast. The cattle are again driven into and around the enclosure for some hours to tread the grain into the ground, and no further attention is paid to the crop till it is ready to be gathered in, some four months later. Even with this rough method of cultivation large crops are produced in the rich llano lands. In most parts of the country where there are four seasons it gives two crops in the year—the principal crop in December or January, and the second crop in July or August—at 2,000 to 4,000 feet above the sea-level, at which altitude the best rice is grown; it takes about five months to ripen. Rice is occasionally used instead of maize, for making a sort of chicha.

Plantains.

These form the chief food of the inhabitants of the hot country, and one of the chief articles of food of those of the temperate and cold countries. The productive power of the plantain in Colombia is wonderful. According to calculations made by Boussingault and others, one acre will supply food for twelve persons, and that without the expenditure of any labour to speak of. The number of years during which they can be grown upon the same land seems to be without limit. There are said to be plantations in the country which have been planted with them annually for the last eighty or ninety years without manure, and without the rotation of any other crop. There are many varieties grown—from the large plantains, only fit for cooking, to the small edible fruits about three inches long. The fruit ripens in a year after planting in the hot country, and in from 18 to 20 months in the temperate climates.

Manioc, Cassava, or Yuca.

Though this well-known plant is not so universally used in Colombia as in some other parts of South America, it is nevertheless a common and useful article of food. The sweet cassava (*Manihot aipi*) is the commonest, the poisonous or bitter sort (*Manihot utilissima*) being rarely met with. One of its chief advantages is that it will remain in the ground for a long time after being fully ripe without being spoilt. It ripens in a year or rather less in the hottest districts, but may be left without suffering damage for six months longer. It is never made into tapioca in Colombia, but is used as a vegetable or made into bread.

The Vegetable Ivory Palm (Phytelephas macrocarpa),

And the plant from which Panama hats are made (*Carludovica palmata*), are two of the most important plants of the hot country. The former grows in large quantities in the damp forests of the valley of the Magdalena, and over 6,000,000 lbs. of nuts are exported yearly. The latter is found over most of the country, and the manufacture of hats from its leaves forms the chief industry in many districts.

Scarcely any plant cultivated in Colombia can be said to be confined exclusively to the temperate zone, except, perhaps, coca; but others, such as coffee and arracacha, do best within its limits.

Coca (Erythroxylon Coca)

Is now but little grown. It is only in general use as an article of daily consumption in the south of the department of Cauca, where it is the custom to hire labourers at so many reals a day and so much coca. But it is grown in small quantities in several parts of the country, and used mostly by Indians. It is also sold for medicinal purposes in the markets of most of the large towns. At the time of the conquest it was in general use all over the country, but the use of it gradually died out. The recent demand for coca for the extraction of cocaine does not seem to have stimulated its cultivation in any part of the country. About 1,000 lbs. were exported last year.

Coffee.

This is said to thrive best at from 3,000 to 5,000 feet, though it is grown at much lower elevations. It is the one crop whose cultivation has largely increased in the last few years, and it has taken the place of cinchona bark as the chief export of the country. This production, though it is large compared with that of other coffee-growing countries, might be increased by more careful cultivation, and above all by the employment of better machinery for cleaning and preparing the berry for packing.

Arracacha (Arracacia esculenta).

The root of this plant is second only to the potato in importance in Colombia. It is an excellent food for cattle, horses, mules, and other animals, and they often prefer it to other food. It is most useful in cases of animals recently imported from Europe, which, on their first arrival, seem to take more readily to it than to any other food obtainable in the tropics. As it takes a full year to ripen, and cannot stand a sharp frost or severe heat, there are few if any parts of Europe where it could be introduced.

Potato (Solanum tuberosum).

This well-known esculent grows wild in some districts of the Colombian Andes, especially in the mountain region called the Paramo de las Papas (Potato Mountain), in the south of the Department of the Cauca, at great altitudes. It is very productive, and of fine quality over all the cold districts of the country. It has probably been cultivated for many centuries, as the Spaniards upon their arrival in the country found many plantations of it, especially in the south of the Cauca. The potato is the chief food of the cold country. Two principal varieties are grown—the criollas, which are red-skinned and yellow or orange-coloured inside; and the ordinary white potato, which has no special name, but is called sebanera or paramuña, according to whether it is grown on the savana or on the mountains. Those grown on the mountain sides over 9,000 feet, are the largest and best. The ordinary potato only gives one crop a year; the criolla gives two, or sometimes three, in good savana land. The production has greatly decreased since the potato disease attacked the crops in 1865, before which date it was unknown in Colombia. From that time onwards, though present every year, it has decreased in intensity year by year, varying according to the amount of rainfall. In the first year (1865) the disease developed so rapidly that a large number of potato fields were entirely destroyed in a few days. The greater the altitude the less tendency there seems to be to the disease, and potatoes grown at an elevation of from 9,000 to 10,000 feet are almost if not entirely free from it. It has been suggested that the absence of the disease is due to the fact that the potatoes are generally planted very wide apart on the mountains, or that there is a free circulation of air at that altitude.

American Aloe (Agave americana).

This is known by the name of Figue in Colombia. Though rather a wild than a cultivated plant, it is of great importance on account of the numerous uses to which the fibre is applied. It grows wild in all climates and soils from the sea-level to 10,000 feet. Most of the hedges are formed of it in many parts of the country, and it is planted here and there on waste patches of land in the districts where the industry of extracting the fibre is carried on, but the wild plants are nearly sufficient for the demand. The leaves are picked off one by one when they have arrived at the proper age, but generally not till after the plant has produced its flower-stem; soon after that the plant dies, and is reproduced by another grown from a shoot. The mode of extracting the fibre is very slow and laborious. The leaves are soaked in water and then beaten with sticks or mallets on a board or smooth stone, and the fibre picked out by hand with the aid of a knife. A skilled and practised labourer can only produce some 10 lbs. of fibre a day by this method. A simple, easily-worked, and above all a cheap machine, not too heavy to be carried over mountain roads, in pieces at least, would be of great service, and would largely increase the production. The number of plants now grown is limited by the capacity of the people to extract the fibre; any quantity conld be planted without cost or labour, and if a machine were introduced such as the people could afford to buy, and easily learn to use, the prices of all articles made of the fibre could be considerably reduced. The chief uses of the fibre in Colombia are in the manufacture of the alpargates or sandals, used in place of boots, shoes, and stockings, by a large proportion of the poorer classes—perhaps one-half of the people—for sacks, for ropes, girths, pack-saddles, and other horse furniture, which is a large item in a country where all transport is by mule-back, and for numerous other purposes. No other part of the plant but the fibre is used. The Mexican drink "pulque," made from the same plant, is unknown in Colombia.

Cinchonas.

The cultivation of the species of cinchona on a large scale in Colombia is rather a dream of the

future than an accomplished fact, though the eminent suitability of the soil and climate in those districts where it was originally found wild are almost a guarantee for its success when attempted. In 1884 the Government of the Republic passed a law for the purpose of promoting the planting of cinchona, india-rubber, cacao, and eucalyptus trees. This law authorised the President to award prizes for the planting of cinchona trees at the rate of 1,000 dols. for each 10,000 trees, to be payable when the trees had arrived at the age for cropping. The trees to be planted were required to be of certain species—*C. Ledgeriana*, *C. officinalis*, *C. lancifolia*, and *C. pitayensis*. Certain smaller prizes were also to be given for the planting of caoutchouc trees, and especially of a native species called "Caucho virgen," which grows in the cold country from 6,000 feet upwards. The President was also authorised to purchase up to 1,000,000 trees for distribution to intending planters. This law has remained a dead letter, however; no prize has been awarded under its provisions, and no new plantations have been made since it was passed.

There are three important plantations in Colombia at present; the oldest is near the village of Colombia, in the south of Tolima, belonging to the Compania de Colombia, a company which for many years exported large quantities of the bark of the native *C. lancifolia*, whilst the supply of the wild trees held out. Their plantation is composed of 80,000 trees, all *C. lancifolia*, and is situated exactly where the wild trees formerly grew. They have lately sent small quantities of the cultivated bark to Europe, and the quality is pronounced to be fine, with about 6 per cent. of quinine. Another plantation, also in Tolima at Chaparral, on the central Cordillera, has 450,000 trees from one and a-half to five years old, many fit for cropping. The owners have secured the services of Mr. Robert Thomson, formerly Superintendent of the Botanical Gardens, Jamaica, to manage the plantation. The trees there are of various sorts, including *C. Ledgeriana*, *C. succirubra*, *C. officinalis*, &c., besides the native species. The third plantation is near Bogota. These companies have exported little cultivated bark as yet, owing to the low price of quinine in Europe, and are waiting in expectation of a possible rise in the price—an expectation which, however, seems little likely to be realised when the market price of quinine is, at the present time, down to a little over 1s. an ounce, and there seems no prospect of any great advancement.

Of the two indigenous species, *C. lancifolia* and *C. pitayensis*, cultivated in the country, the former is the more valuable from the amount of quinine it contains, but it contains only a small quantity of other alkaloids. The *C. pitayensis*, on the contrary, is not very rich in quinine, but is the richest known bark in the valuable alkaloid quinidine—it is, in fact, the only variety containing quinidine in anything like considerable quantities. The Chapparel plantatio is close to the district in which the *C. pitayensis* tree originally grew. The best altitude for the cultivation of the valuable barks in Colombia is from 6,000 to 8,500 feet, in a temperature of 56° to 62°.

The tree producing the cuprea bark, *Remijia purdieana*, which grows as low as 2,009 feet, is not worth cultivating. The large exportation of this bark in 1881-83, which somewhat disturbed the minds of the planters in India and Ceylon, has nearly ceased. It was profitable only as long as the tree existed wild in large quantities within reach of the Magdalena River, and whilst the price of quinine was high. The allied species, *Remijia pedunculata*, which is to be found in considerable quantities on the slopes of the mountains bordering the llanos, has not been largely exported, owing to the cost of transport.

With regard to native fruits, such as pineapples, oranges, mangoes, cherimoyas, &c., it is stated that they are exceedingly cheap, even in the Bogota market, in most parts of the hot country they have no value at all. They grow very abundantly and spontaneously, and without any sort of cultivation, but, except within reach of a market, such as Bogota, few people care for them or take the trouble to pick them, such fruits as guavas, oranges, and mangoes, abound in many districts, and are allowed to fall and rot on the ground by thousands.

Correspondence.

LIVERPOOL (VYRNWY) WATERWORKS.

The remarks of Mr. Hawksley in the *Journal of the Society of Arts*, dated the 7th inst., upon the concluding portion of an article which appeared in the *Journal* of the 17th ult., have just come to my notice.

Your statement in that article, as to the engineers of the Vyrnwy works, is strictly correct. The Corporation of Liverpool never even suggested to me that I should take the office of resident engineer. The Corporation accepted the scheme I had projected by descriptions and plans in the years 1877 and 1878. They instructed me to carry out the necessary further researches and surveys, and in 1879 to prepare the Parliamentary plans, which I did. In September of that year, when those plans were nearly completed, the Corporation asked Mr. Hawksley to become joint engineer with me for the purpose of promoting the scheme in Parliament. This Mr. Hawksley did.

The sanction of Parliament having been obtained for the works, I received in 1881, under the seal of the Corporation, the appointment of "engineer in conjunction with Mr. Hawksley," and that office I held until Mr. Hawksley's resignation in 1885, since which time the whole conduct of the design of the works, now drawing near completion, has devolved upon me.

The general design of the undertaking was therefore my own. The subsequent detailed designs of the works as actually executed were in part Mr. Hawksley's, and in part—certainly not less—my own.

GEORGE F. DEACON.

Liverpool, June 15, 1889.

SCIENCE OF VENTILATION AS APPLIED TO THE INTERIOR OF BUILDINGS.

I perceive that you have opened your columns to correspondence on this subject, and therefore send you the following :—

The supposed identity, to which reference is made, between my system and that upon which the Society's hall is ventilated, is superficial and not real.

As regards the other observations of your correspondent in the issue of 14th inst., he formerly occupied a very large place in the controversy here, to which I referred in my reply at the close of the debate. I should be sorry to lead to a repetition, in your columns, of that correspondence, which was voluminous and proved to so little purpose. It was in consequence of the extent to which it had wandered from accuracy on questions of fact that I found it necessary, in order to bring matters to a point, to make the definite offer to which your correspondent refers as my £50 challenge, which was, and remains, applicable to all or any of the parties to the controversy, and was brought under the particular notice of your present correspondent in my final short letter as follows :—" Mr. Buchan is as retiring as 'G. B.' himself on the point of the definite offer I have made and repeated, whilst he sneers at my reference to the fundamental principles underlying the subject. I am unable to separate the description of the practice from the consideration of the principles on which it rests, and as he was present at my lecture I cannot give him any additional information ; whilst, at the conclusion of the debate before the Philosophical Society, I gave an incontrovertible reason why I cannot enter upon discussion with him."

D. G. HOEY.

Commercial Bank Buildings,
8, Gordon-street, Glasgow,
June 18th, 1889.

Obituary.

DR. PERCY, F.R.S.—This distinguished metallurgist, to whom, as will be seen in page 655 of the present number of the *Journal*, the Council of the Society of Arts (with the approval of His Royal Highness the President) have awarded the Albert Medal for the present year, died on the morning of the 20th inst. It will be a satisfaction to the many friends who regret his loss to know that although Dr. Percy lived so short a time after the award, he received the intelligence of the honour done to him before his death.

John Percy, M.D., was born at Nottingham in 1817, and educated in Paris and in Edinburgh. At the latter University he was a pupil of Sir Charles Bell, and there graduated M.D. In 1851, he was appointed Professor of Metallurgy in the School of Mines, an office which he held until 1879. He was elected a Fellow of the Royal Society in 1847, and in 1883 the freedom of the Turners' Company was presented to him. His great work on "Metallurgy" was commenced in 1861, and continued in 1864, 1870, and 1880; and in 1877 the Iron and Steel Institute awarded their Bessemer medal to him for his researches on metallurgy, especially for those on iron and steel. In 1886 he was elected President of the Institute. Dr. Percy's labours in connection with the science of ventilation were long continued, and for many years he had the control of the ventilation of the Houses of Parliament. Dr. Percy was not renowned alone for his scientific attainments, for his name was well known in art circles, on account of his knowledge of art, and as the collector of a magnificent historical series of English water-colour drawings.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, JUNE 24...Geographical, University of London, Burlington-gardens, W., 8½ p.m.

TUESDAY, JUNE 25...Sanitary Institute, 74A, Margaret-street, W., 5 p.m. Dr. E. Seaton, "The Infectious Hospitals of London as a Defence against Epidemics."

Statistical, School of Mines, Jermyn-street, S.W., 7¾ p.m. Dr. G. B. Longstaff, "Suggestions for the Census of 1891."

Anthropological, 3, Hanover-square, W., 8½ p.m. 1. Prof. Victor Horsley, "Exhibition of some Examples of Pre-historic Trephining and Skull-boring from America." 2. Mr. H. E. Governor Moloney, "Exhibition of Cross-bows, Long-bows, Quivers, &c., of Yoruba." 3. Mr. Henry Balfour, "The Structures and Affinities of the Composite Bow." 4. Rev. R. H. Codrington, "Poisoned Arrows."

WEDNESDAY, JUNE 26...SOCIETY OF ARTS, John-street, Adelphi, W.C., 4 p.m. Annual General Meeting.

Royal Society of Literature, 21, Delahay-street, S.W., 1 p.m.

Patent Agents, 19, Southampton-buildings, W.C., 7 p.m. Mr. A. M. Clark, "The Contemplated Reforms in the Patent-law of France."

FRIDAY, JUNE 28...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8½ p.m. *Conversazione* at the South Kensington Museum.

United Service Inst., Whitehall-yard, 3 p.m. Mr. C. E. H. Chadwycke Healey, "The Naval Volunteers."

Quekett Microscopical Club, University College, W.C., 8 p.m.

Browning, University College, W.C., 8 p.m. Paper by the Rev. J. J. G. Graham.

SATURDAY, JUNE 29...Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m.

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FRIDAY, JUNE 28, 1889.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CONVERSAZIONE.

The Society's Conversazione will take place at the South Kensington Museum (by permission of the Lords of the Committee of Council on Education), this evening, Friday, 28th June.

Proceedings of the Society.

ANNUAL GENERAL MEETING.

The Annual General Meeting for receiving the report from the Council, and the Treasurers' Statement of Receipts, Payments, and Expenditure during the past year, and also for the Election of Officers, was held, in accordance with the Bye-laws, on Wednesday last, the 26th instant, at four p.m., Sir Philip Cunliffe-Owen, K.C.B., K.C.M.G., C.I.E., Vice-President, in the chair.

The Secretary read a letter he had received from the Duke of Abercorn, C.B., Chairman of the Council, explaining that his Grace was confined to his room by a sudden attack of rheumatism, and regretting his inability to take the chair.

The Secretary read the notice convening the meeting, and the minutes of the previous annual general meeting.

The following candidates were proposed, balloted for, and duly elected members of the Society:—

Bagot, Lord, Blithfield, Rugeley, Staffordshire.
Beaumont, Percy Munro, Maldon, Essex.
Bettger, Alfred, 21, Victoria-road, Kilburn, N.W.
Clements, Albert C., 96, Wood-street, E.C., and 3, Vernon-chambers, Southampton-row, W.C.
Cleminson, James, Villa Albano, Norwood, S.E.
Dexter, Frederick George, Gas Works, Wantage, Berks.
Hart, John William, Thatched House Club, St. James's-street, S.W.
Hartridge, William, 6, Drapers'-gardens, E.C.
Hawes, Edward, M.A., 7, Great Winchester-street, E.C.; and Richmond, Surrey.
Hepburn, William Arnold, Leathersellers'-hall, St. Helen's-place, E.C.
Johnson, Edward Sutton, Littleover-hill, Derby.
King, Herbert, Ilford, Essex.
King, Joseph Edmund Sheppard, 38, Tulse-hill, S.W., and 16, Finsbury-circus, E.C.
Mackinnon, Benjamin Thomas, Lloyds, E.C., and Roseneath, Muswell-hill-road, Highgate, N.
Mainland, George Edward, Glenthorpe, Woodside-lane, North Finchley, N.
Matthews, Willliam Macdonald, 4, Nelson-crescent, Ramsgate.
Melville, Viscount, Melville Castle, Lasswade, Midlothian.
Metcalfe, Sir Charles Herbert Theophilus, Bart., 2, Victoria-mansions, S.W.
Milbank, Frederick Henry, 13, Upper Hamilton-terrace, N.W.
Morgan, Walter Vaughan, 42, Cannon-street, E.C.
Morris, William, 4, St. Paul's-road, Camden-square, N.W.
Pannell, William Henry, 13, Basinghall-street, E.C.
Partridge, Deputy-Surgeon-General Samuel Bowen, Thicket-lodge, Thicket-road, Anerley, S.E.
Pritchett, Robert Taylor, 4, Norland-terrace, Holland-park. W.
Punchard, William Charles, 151, Cannon-street, E.C.
Rothschild, Leopold de, New-court, St. Swithin's-lane, E.C.
Seyd, Julius A., 32, Dover-street, W.
Tapscott, Robert Lethbridge, 41, Parkfield-road, Liverpool.
Walker, Thomas A., 65, King-street, Manchester.
White, Harry Dow, 15, New Broad-street, E.C.

The Chairman nominated Mr. Major Hawkins and Mr. T. C. Townsend, scrutineers, and declared the ballot open.

The Secretary then read the following:—

ANNUAL REPORT.

I.—Ordinary Meetings.

In the Opening Address which, according to custom, the Duke of Abercorn, as Chairman of the Council, delivered at the beginning of

the Session, the subject dealt with was the very important and interesting one of Irish Industries, a subject with which the Duke of Abercorn is necessarily specially familiar, and to his treatment of which his long experience as an Irish landlord gave considerable weight. The first two evenings of the Session after the opening meeting were devoted to papers, one the "Phonograph" and another on the "Graphophone," the first by Colonel Gouraud, and the second by Mr. Henry Edmunds. Both were very largely attended by members, as these meetings formed the first occasions on which these marvellous instruments were introduced to the London public. By the kindness of the owners of the instruments they were kept on view for several days after the papers had been read, so that members of the Society of Arts had a full opportunity of testing their remarkable capacities, and the improvements that had been made on the original instrument of Edison, introduced to the Society by Mr. Preece, in his paper read May 8, 1878* At the other meetings before Christmas papers were read by Mr. W. H. Deering, on "Explosives," and by Mr. W. J. Dibdin, on "Standards of Light." Mr. Deering has long been working with Sir Frederick Abel on the subject he dealt with; and Mr. Dibdin was not only specially appointed by the Metropolitan Board of Works to make a report on this subject, but he has since, as a member of the Committee appointed by the British Association to deal with this subject, been carrying on his researches. The practical conclusion of the labours of Mr. Dibdin and his colleagues, as formulated in the paper, may be said to be that an excellent trustworthy standard exists in the Amyl-Acetate lamp, but that all endeavours to obtain a scientific unit of light have up to the present been unsuccessful. At the first meeting after Christmas Colonel Hozier again brought before the Society the subject of the "Channel Tunnel," Sir Frederick Bramwell, the well-known advocate of the scheme, being in the chair. Another paper of an engineering character was read a few weeks later by Mr. Benjamin Baker, his subject being the "Forth Bridge," certainly one of the most remarkable engineering works of our time. As a somewhat striking illustration of the character of the work, it may be noted that each cantilever, or half span of the bridge—and there are four of these cantilevers—is nearly as large as the Paris Eiffel Tower, the cantilevers of course being horizontal, whereas the tower is vertical. Mechanical engineering was represented in a papers by Professor Kennedy on the Society's Motor Trials, the discussion on which extended over a second evening; and in Mr. Yarrow's paper on "The Use of Spirit as an Agent in Prime-movers." In the engine, applied principally by Mr. Yarrow to the propulsion of launches, steam is replaced by the vapour of petroleum spirit. Such engines, with their generators, are lighter than steam-engines, and occupy less space. It is claimed as a practical result that there is considerable economy in working. There were three papers on subjects connected with electric lighting, one by Mr. Forbes on "Electric Meters at Central Stations;" one by Professor Silvanus Thompson on "Arc Lamps;" and one by Mr. W. H. Preece on "Secondary Batteries." Two papers dealt with sanitary subjects, that by Sir Douglas Galton on "The Sanitary Functions of County Councils," and that by Mr. Hoey on "The Science of Ventilation as applied to the Interior of Buildings." The subject of County Councils was also brought before the Society by Mr. G. L. Gomme, at a very appropriate moment, early in February, just as the London County Council were entering upon the active discharge of its functions. Mr. William Anderson, in his paper on "Aluminium," brought before the Society a most important recent application of scientific chemistry to metallurgical industry. Cheap aluminium has long been a desideratum; and if the hopes of the projectors are at all borne out by results, cheap aluminium has now been attained by the process described by Mr. Anderson. Mr. Conrad Beck made a useful contribution to a subject which has frequently of late years been before the Society, in his paper on "Photographic Lenses." Mr. Clulow treated a matter of special and curious interest in his paper on "Playing Cards." Mr. Paul, in his paper on "Fruit Growing," gave an opportunity for discussing a subject which has occasioned a great deal of newspaper correspondence during the present year. Mr. Alan Cole, whose efforts to promote the lace industry in Ireland are well known, read an interesting paper thereon; and Mr. Simmonds added one more to the many useful papers he has read before the Society, by giving it an exhaustive account of the production and applications of salt. A question of great importance to Londoners was brought before the Society by Mr. J. S. Jeans, in his paper on "Street Traffic." From this sum-

* *Journal*, vol. 26, p. 533.

mary it will be seen that the papers which the members have had an opportunity of attending during the past Session have not been inferior either in value or in variety of interest to those which have been read in any previous Sessions.

II.—Indian Section.

Six papers on a variety of subjects connected more or less intimately with our Eastern dependency, were read before the Indian Section during the past session. The opening meeting of the present year was held on 25th January, when Mr H. H. Johnston, the newly appointed British consul for Portuguese East Africa, read a paper on the "Asiatic Colonisation of East Africa." The reader gave an interesting account of the settlements established by natives of India within the Zanzibar territory, and of the flourishing trade between that portion of the Dark Continent and Bombay. Sir Frederick Goldsmid, who presided on this occasion, was able to testify from the ample stores of his knowledge to the general accuracy of Mr. Johnston's conclusions. The second paper, on the 15th February, related to a subject, which for more than one reason has attracted a good deal of public attention, viz., "The Ruby Mines of Burmah." Mr. George Skelton Streeter, who had twice visited the district, supplied on this occasion a very graphic and detailed account of the mining district, and of the system on which the mines were worked by their Burmese owners. Sir Charles Bernard, who occupied the chair, contributed much valuable information to the subject, derived from his long and intimate acquaintance with the country, both before and after the annexation of Theebaw's dominions. The third meeting of the section was on 8th March, when Professor Wallace, of Edinburgh University, read an interesting paper on "Indian Agriculture." On 29th March, that which may be termed the most important and permanently valuable paper of the whole session, was contributed by Sir Juland Danvers, K.C.S.I., on "The Progress of the Railways and the Trade of India." Sir Juland's connection with Indian railways dates from their infancy, and those who refer to his paper will find that it contains an infinite amount of pertinent information, besides a summarised history of the extension of railways throughout the Indian peninsula. These four papers were illustrated by means of lantern slides. The fifth paper was entitled "The Karún Valley as an avenue of Trade," and was read on 3rd May by Major-General Sir R. Murdoch Smith, whose long connection with the telegraphs of Persia entitled him to speak with exceptional authority on the feasibility of developing the south-west portion of the Shah's kingdom by means of its one navigable river. Sir Lepel Griffin presided on this occasion, and incidentally referred to the Shah's intended concession for the development of his country. The sixth and last meeting of the session was held on 31st May, when Mr. John McDougall read a paper of much interest on "Indian Wheats." On the whole the papers were fully up to the high average of their predecessors, and several of them supplied data not easily procurable elsewhere.

III.—Foreign and Colonial Section.

The first meeting of this Section was held on the 29th January, when Mr. T. W. Goad read a paper on Colorado, with special reference to its mining industries. On the 19th February, Commander V. Lovett Cameron delivered an address upon "Slavery in its Relation to Trade in Tropical Africa," and explained the means by which he hoped that the traffic in slaves could be gradually put down. On the 26th March, Mr. Robert Pritchett read a paper on Borneo, in which he described its scenery, products, and industries. Stress was laid both by him and in the discussion which followed the paper on the growing importance of the tobacco trade. Mr. Pritchett exhibited an interesting collection of sketches and native implements. On the 2nd April, Mr. F. K. Smythies read a paper on the Argentine Republic. He described the rapid progress which has been made by this country, especially since it has enjoyed a settled Government, and drew attention to its advantages as a field for emigration. Captain Wiggins read a paper on the 30th April on "The Northern Waterway," or new ocean route to Siberia *viá* the Kara Sea and the River Obi. He described the various expeditions which he had made by this route, and also the resources of the country, which would, by its use, be opened up to British trade. The paper was illustrated by an interesting collection of views of Siberian towns and races. A paper written by Mr. Schallenberger, engineer to the Westinghouse Electric Company, was to have been read on the 28th May by Mr. Humbird, assistant general manager of that company, on "The Westinghouse Alternating System of Central Station Electric Lighting in the United States of America." Unfortunately, however, the paper was delayed in transit, and did not arrive in

time for the meeting, which had therefore to be unavoidably abandoned.

IV.—Applied Art Section.

The first meeting of this Section was held on January 22nd, when Sir James D. Linton, P.R.I., delivered an address on "Some Recent Movements in Relation to the Applied Arts." In this paper Sir James Linton suggested a reconstitution of the old guilds to suit modern needs, so that each craft should have its own particular guild, and all workers in each craft should have the right of belonging to their own guild. A governing guild, which should be the means of communication between all the crafts, was further proposed. Mr. Carlo Giuliano's paper on "The Art of the Jeweller," read on March 19th, dealt with a somewhat similar proposal. Mr. Giuliano strongly advocated a return to the apprenticeship system, and urged the need of examination for the craftsman. On February 5th an important paper on "The Manufacture of Sèvres Porcelain" was read. The paper was by M. Edouard Garnier, late art director at the Sèvres manufactory, and contained a full history of the manufacture. M. Garnier was prevented from attending the meeting, and the paper was therefore read by Mr. Starkie Gardner, who communicated some additional notes on the subject to the meeting. Mr. W. H. J. Weale gave the Society the results of a large amount of original research in his valuable paper on "English Bookbinding in the Reigns of Henry VII. and Henry VIII.," which was read on February 26th. Mr. H. H. Statham, who delivered a course of Cantor lectures on "The Elements of Architectural Design" before the Society in 1887, took up a subject which he had only slightly alluded to in one of those lectures, and read a singularly interesting paper on "Architecture in its Relation to Landscape" on April 9th. The paper was illustrated by a large series of lantern slides, in which were shown examples of the various points raised by Mr. Statham in the elaboration of his argument. The last paper of the series was on "Venetian Glass," by Dr. Salviati, which was delivered on May 14th. Some beautiful specimens of the glass were shown at the meeting as illustrating different classes of work.

V.—Cantor Lectures.

The subjects of the Cantor Lectures for the past Session have been tolerably equally divided between applied science and applied art. In the first course Captain Abney gave an account of the valuable and original researches which he has made into the measurement of light and colour. It is not too much to say that Captain Abney has established a definite standard for colour—a standard which can be reproduced with entire accuracy at any time, and that he has at all events suggested a method which may not improbably result in the attainment of a standard for the measurement of light. A subject of a kindred nature, but treated in a different manner, was dealt with by Mr. C. V. Boys in his course on "Instruments for the Measurement of Heat." Mr. Boys's skill as a practical demonstrator of scientific subjects is well known to all who take an interest in physical science; and those who had the opportunity of attending his latest course of lectures will not readily forget the beautiful manner in which he applied the very simplest materials to the illustration of scientific principles. Another valuable and thoroughly practical course was given by Mr. Graham Harris on "Heat Engines other than Steam." In it the whole of a very difficult subject was treated as exhaustively as the limits of space permitted, and in a manner at once scientific and popular. It would be difficult to find a clearer exposition of the present state of a branch of applied science in which rapid improvements have recently been introduced, and in which it is tolerably certain that still greater advances will before long be made. This gives a special value to this course of lectures. Mr. Alan Cole has on several occasions addressed the Society on subjects connected with the decoration and artistic treatment of textile fabrics, and in the past Session he gave a short and interesting course on "Egyptian Tapestry." There is perhaps no one more qualified to speak on "Wood Engraving" than Mr. W. J. Linton, and the Society was fortunate in obtaining two lectures from him on the subject. Mr. Walter Crane's course on "The Decoration and Illustration of Books" derived special value from the very beautiful illustrations with which they were accompanied.

VI.—Juvenile Lectures.

The usual course of Juvenile Lectures was given during the Christmas holidays by Prof. H. E. Armstrong, F.R.S., the title being, "How Chemists Work—an example to Boys and Girls." Prof. Armstrong's object was to show how the principal elements of chemical knowledge might be imparted at a very early

age, and to prove that instruction in chemistry properly given formed a perfectly satisfactory instrument of mental training. In order to show the results which might be thus obtained, Prof. Armstrong employed his own two little sons as his demonstrators, and very efficiently and well the boys performed their work.

VII.—Albert Medal.

The Albert Metal for the present year has been awarded to Dr. John Percy, F.R.S., for his achievements in promoting the arts, manufactures, and commerce, through the worldwide influence which his researches and writings have had upon the progress of the science and practice of metallurgy. Dr. Percy's work on "Metallurgy" has long been, and probably will long remain, the standard book on the subject not only in English but in every other language, while the influence he exerted during his twenty-eight years' tenure of the Professorship of Metallurgy at the Royal School of Mines to a great extent directed the course of investigation, at all events in this country, in the subjects of his teaching. To the instructions of Dr. Percy, and to his writings, may fairly be attributed no small share of the great progress in metallurgical science and industry which the present generation has seen. The Council of the Society are glad that the award of the Albert Medal to Dr. Percy, as a record of the appreciation by the Society of his life-long labours, was made in time for him to receive the intelligence before he succumbed to the long illness which has so recently removed him from among us.

VIII.—Medals.

The Council have awarded eleven medals for papers read during the past Session. Of these, six have been for papers read at the Ordinary Meetings, two for papers in the Indian Section, two in the Section of Applied Art, and one in the Foreign and Colonial Section.

The following is the full list of awards:—

To W. H. Deering, F.C.S., for his paper on "Explosives."

To W. J. Dibdin, F.I.C., F.C.S., for his paper on "Standards of Light."

To Conrad Beck, for his paper on "The Construction of Photographic Lenses."

To Prof. Silvanus P. Thompson, for his paper on "Arc Lamps and their Mechanism."

To Prof. A. B. W. Kennedy, F.R.S., for his paper on "Objects and Methods of the Society of Arts' Motor Trials."

To George Clulow, for his paper on the "Origin and Manufacture of Playing Cards."

To Capt. Wiggins, F.R.G.S., for his paper on "The Northern Waterway to Siberia."

To Major.-Gen. Sir R. Murdoch Smith, K.C.M.G., for his paper on "The Karún as a Trade Route."

To John McDougall, for his paper on "Indian Wheats."

To Sir James D. Linton, P.R.I., for his paper on "Some Recent Movements in Relation to the Applied Arts."

To H. H. Statham, for his paper on "Architecture in Relation to Landscape."

Thanks were voted to the following Members of the Council for the papers read by them:—

To Benjamin Baker, M.Inst.C.E., for his paper on "The Forth Bridge."

To William Anderson, M.Inst.C.E., for his paper on "Aluminium and its Manufacture on the Deville-Castner Process."

To Sir Juland Danvers, K.C.S.I., for his paper on "The Progress of Railways and Trade of India."

IX.—Prizes for Art Workmanship.

The Council, in renewing the offer of prizes for art workmanship, decided to reduce the number of subjects to pottery, stone-carving, and wrought iron grilles. To these were added prizes for goldsmiths' and silversmiths' work, for which the amount of £50 was placed at the disposal of the Society by the Goldsmiths' Company. A large number of objects were sent in in response to this offer, and these were exhibited in the Society's rooms in May last.* Twelve prizes, amounting in value to £95 were awarded in the class of Pottery; honourable mention was also made of several objects in this class. Four prizes for carved capitals of columns, amounting to £45 were awarded in the class of Stone Carving. In the class of Wrought Iron, three prizes, amounting to £45, were awarded for grilles, and, in addition, all the work sent in for competition was highly commended. A second prize of £5 only was awarded in the class of Goldsmiths' and Silversmiths' Work, and, therefore, £45 were returned to the Goldsmiths' Company. The Council consider it very unsatisfactory that there should have been so limited a response to the offer of the Goldsmiths' Company.

After due consideration, it has been decided by the Council to discontinue the present system under which prizes for Art Workman-

* A catalogue of the Exhibition will be found in the *Journal* for May 1, p. 552, and a list of the prizes in the next number, p. 559.

ship are offered, and in lieu of it to offer prizes in connection with the Exhibition of the Arts and Crafts Society, to be held in the autumn of the present year.

X.—Arts and Crafts Exhibition.

The Council, on the recommendation of the Committee of the Applied Art Section, have, as above stated, considered the advisability of altering the arrangements connected with the offer of prizes for art workmanship, and on the recommendation of a joint Committee of members of their own body and of the Arts and Crafts Exhibition Society, they have resolved to offer, provided works of sufficient merit be forthcoming, the sum of £150 in money prizes as well as twenty of the Society of Arts Bronze Medals, for objects in the Arts and Crafts Exibition to be held in the autumn of the present year. In accepting the offer the Committee of the Arts and Crafts Exhibition Society made the stipulation that they should have nothing to do with the adjudication of the prizes, and also that members of the Arts and Crafts Society should not compete for the prizes. The Judges will be empowered to distribute the money in any sums they think will best meet the relative merits of the exhibits, at the same time paying due regard to the cost of production. The general rules under which the prizes will be offered will be substantially the same as those under which the art workmanship competitions have been carried out.

The Arts and Crafts Exhibition Society was formed in 1888, with a similar object to that of the Council of the Society of Arts, when they instituted the scheme of Art Workmanship Prizes, viz., to draw out and encourage the artistic craftsman. The first exhibition was held in the autumn of the year, and was so successful that the guarantors (among whom the Society of Arts was one) were not called upon for any contribution towards the expenses.

XI.—Owen Jones Prizes.

These prizes have been awarded annually for the past ten years (since 1879) on the results of the annual competition of the Science and Art Department to students of the Schools of Art, who produce the best designs for household furniture, &c., on the principles laid down by Owen Jones. As usual, six prizes were offered for competition last year, each prize consisting of a bound copy of Owen Jones's "Principles of Design" and a Bronze Medal. A list of the successful candidates has appeared in the *Journal*.* A similar number of prizes has been offered for the present year (1889), and the result of the competition will be published in the *Journal* as soon as it is received from the Science and Art Department.

XII.—Swiney Prize.

The quinquennial award of the Swiney prize was made last January. Dr. Swiney died in 1844, and in his will he left the sum of £5,000 Consols to the Society of Arts, for the purpose of presenting a prize, every fifth anniversary of the testator's death, to the author of "the best published work on Jurisprudence." The prize is a cup value £100, and money to the same amount; the award is made jointly by the Society of Arts and the College of Physicians. The cup now given is in accordance with a design specially prepared in 1849 for the first award, by Maclise.

Following the usual practice, a joint Committee of the Society of Arts and the College of Physicians considered the award, and on their report the prize was awarded to Charles Meymott Tidy, for his work on "Legal Medicine," by a meeting of the adjudicators held on the 21st January last. †

When the prize was first instituted, an understanding was arrived at between the College of Physicians and the Society of Arts that it should be given alternately to General Jurisprudence and to Medical Jurisprudence, and this arrangement has since been carried into effect. As, however, it is the opinion of the Council of the Society that the time has come when the matter should be reconsidered, a communication on the subject has been addressed to the Council of the College, and negotiations are still pending between the two bodies.

Jurisprudence is a wide subject ; many works of importance are written upon it. Medical Jurisprudence is a department of the larger subject, and few works of importance are written upon it. An arrangement by which one-half of the Swiney Prize awards is devoted to a comparatively small department or branch of the general subject, must inevitably result in the awards being made too frequently in respect of that one branch. And even if that were not so, it must be admitted that any preconcerted arrangement unnecessarily ties the hands of the adjudicators, who should on each occasion honestly strive to find

* August 17th, 1888, vol. xxxvi., 981.

† See *Journal*, January 25th, 1889.

out the best work, irrespective of any other consideration.

It may conceivably happen that the medical members of the Committee would be unanimous in favour of a work on Medical Jurisprudence, and the other members of some other work, but this could hardly happen, unless both works were of admitted merit. In such a case, no doubt, some way must be found of determining who shall have the prize. As a last resource, it might not be improper to let there be an understanding that whenever matters are so nicely balanced, and there is no other way of coming to a decision, the scale shall be made to incline alternately in one direction and in the other, but the Council now consider that no rule should be kept in force which would have the effect of preventing the adjudicators looking on each and every occasion at all works which come within the terms of the bequest; nor should the Committee be bound not to recommend a work merely because it happens not to be the turn of that branch of Jurisprudence to which such work relates, nor to recommend a work only because it happens to be the turn of such branch.

The following is a list of the recipients of the Swiney Prize up to the present date :—

1849. J. A. Paris, M.D., and J. Fonblanque, for their work, "Medical Jurisprudence."

1854. Leone Levi, for his work on "The Commercial Law of the World."

1859. Dr. Alfred Swayne Taylor, F.R.S., for his work on "Medical Jurisprudence."

1864. Sir Henry Sumner Maine, K.C.B., D.C.L., member of the Legislative Council of India, for his work on "Ancient Law."

1869. William Augustus Guy, M.D., for his "Principles of Forensic Medicine."

1874. The Right Hon. Sir Robert Joseph Phillimore, D.C.L., for his "Commentaries on International Law."

1879. Dr. Norman Chevers, for his "Manual of Medical Jurisprudence for India."

1884. Professor Sheldon Amos, for his work, "A Systematic View of the Science of Jurisprudence."

1889. Charles Meymott Tidy, M.B., for his work on "Legal Medicine."

XIII.—Motor Trials.

One of the most important pieces of work completed by the Society during the Session certainly consisted of the Trials of Motors for Electric Lighting, which were successfully carried out in September last by Dr. Hopkinson, Professor Kennedy, and Mr. Beauchamp Tower, as judges for the Society. In the last two Reports of the Council reference has been made to the circumstances which induced the Council to undertake these trials, and to the causes which led to the postponement of the original proposal. Although the number of entries was small, smaller than the Council had been led to anticipate would be the case, it was believed that the scientific results which might be gained would justify the Society in undertaking the expenses and labour of the tests, and in asking the eminent men who consented to serve as judges to devote a very considerable portion of their time at a necessarily inadequate remuneration to the work of the trials. This anticipation has been fully realised. Never before, the Council believe, have any similar comparative tests of gas-engines been made, or with such elaborate measurements. The full report of the judges has already appeared in the *Journal*.* It has also been published separately. It may therefore be sufficient to say here that four gold medals were awarded—one to Messrs. Davey, Paxman, and Co., for their 8 horse-power compound portable steam-engine; one to the British Gas Engine and Engineering Company, for their 6 horse-power Atkinson's "Cycle" gas-engine; one to Messrs. Crossley Brothers, for their 9 horse-power "Otto" gas-engine; and one to Messrs. Dick, Kerr, and Co., for their 8 horse-power "Griffin" gas-engine.

The Council hope that similar trials may be conducted, either by the Society or by some other independent and trustworthy body, after the lapse of sufficient time, and they are convinced that the trials conducted under the auspices of the Society will suffice to form a standard for comparison with whatever may be obtained in future years.

XIV.—Examinations.

It was stated in last year's report that the Council had determined to add to the list of examination subjects the following languages: — Portuguese, Russian, Chinese, Danish, and Greek, a determination which was afterwards modified to the extent of substituting Japanese for modern Greek. The additions proved so far satisfactory that candidates entered in three out of the five new languages, Chinese and Japanese alone failing to attract any students. In the old subjects there has been a very considerable increase, the total number of candidates this

* See *Journal*, Feb. 15, 1889, *ante* p. 213.

year being 1,861, against 1,531 in the preceding year. It is very gratifying to be able to record a steady increase, the numbers as a whole having been gradually going up for some years past, as is shown by the tabular statement appended.

Table showing the Number of Papers Worked in each Subject for the present and for the four preceding years.

Subjects.	1885.	1886.	1887.	1888.	1889.
1. Arithmetic	171	188	108	113	138
2. German	28	40	48	36	66
3. Portuguese*	—	—	—	—	4
4. Russian*	—	—	—	—	2
5. Danish*	—	—	—	—	1
6. Chinese* †	—	—	—	—	—
7. Japanese* †	—	—	—	—	—
8. Book-keeping	336	309	348	591	782
9. Italian	—	—	7	8	5
10. Spanish	24	20	29	17	30
11. Domestic Economy	32	58	58	61	48
12. Political Economy	12	—	—	14	12
13. English	118	100	100	108	80
14. French	96	112	98	116	134
15. Commercial Geography	—	—	—	—	11
16. Theory of Music	243	194	196	182	203
17. Shorthand	253	255	323	285	345
18. Practical Commercial Knowledge* †	—	—	—	—	—
Totals	1,313	1,274	1,315	1,531	1,861

* New subjects.
† No examination was held in these subjects.

Comparing the results of 1889 and 1888, the largest increase is shown in the important subject of Book-keeping, in which there were no less than 782 papers worked, compared with 591 in 1888. In Shorthand, in which owing to the possibly higher standard introduced in 1888, there was a slight falling off last year, this year the numbers have more than recovered, being 345 against 285. The increase is less noticeable in the language subjects. Curiously enough, there is a falling off in English, only 80 candidates against 108 having taken the subject up. Probably many who might have entered took up another language instead, but it is to be hoped that the decrease is only accidental, and that the numbers will rise again in future years. German shows a considerable increase, 66 against 36; Spanish, 30 against 17; French, 134 against 116; while in Italian, again, there are only 5 against 8. The only other subjects in which there has been a decrease are Domestic Economy, 48 compared with 61; and Political Economy, 12 against 14. It is very satisfactory to note that for the first time for several years there has been an examination held in the very important subject of Commercial Geography, 11 candidates having presented themselves.

In the subjects added this year for the first time the number of candidates was, of course, small; they were Portuguese 4, Russian 2, Danish 1. It is to be hoped that next year candidates may be found for Chinese and Japanese. While there are not a few literary students of these languages, the study of their commercial side appears to be neglected, though for practical purposes, and for the use of those who are going to the East, this is much the more important.

As regards the quality of the candidates' work, the reports of the examiners are encouraging. In Shorthand the examiner finds a general improvement. The per-centages of failures is 30, still large, but an improvement on the 35·5 per cent. of 1888, and the 47 per cent. of 1887.

In Arithmetic the examiner considers that the best candidates this year were not equal to the best of last year, with the exception of one who obtained more than 90 per cent. of full marks.

The examiner in Political Economy expresses the opinion that the papers sent in were, "with two exceptions, distinctly above the level of those last year, showing greater precision of thought, clearer grasp of theory, and wider reading." "Upon the whole the work was very well done; and those who obtained First-class, or nearly First-class marks, may be encouraged to pursue their study of the subject, for which they have shown some real aptitude."

The papers in Domestic Economy this year show a marked improvement upon the papers of previous years.

The standard of the Book-keeping papers has risen. The examiner has been able to award a First-class certificate for 19·8 per cent. of the papers worked, while in 1888 the percentage was 16·41, this in itself being an advance on the average of previous years.

The papers sent up for Commercial Geography leave room for improvement, and it may be hoped that, now that a beginning has been made with this important subject, teachers will pay more attention to it, and that there may be in future years candidates in larger numbers and of a more advanced class.

In Theory of Music the standard of the papers worked seems not to have varied very

greatly from that of recent years, and the same remark is applicable to English. In French a slight improvement may be traced. In German the average has fallen, only 19 out of 66 candidates getting a First-class, whereas last year 17 out of 35 did so. In Italian the examiner reports an improvement, and the report on Spanish is also satisfactory.

XV.—Practical Musical Examinations.

The usual examinations in practical music were held in London in May last. There were 225 candidates, 211 of whom passed the examination, taking 224 certificates—83 first class, and 141 second class. Two of the candidates also took second-class honours. It should be stated that many of the candidates were examined in vocal as well as in instrumental music, and consequently the number of certificates awarded does not agree with the total number of candidates passing. There was a slight decrease in the number of candidates, as compared with those of last year, when 259 candidates presented themselves. The number examined in 1887 was 188.

The figures for the two past years and for the present year are as follows:—

	No. of candidates examined.	Certificates gained.	First.	Second.
1887	188	193	61	132
1888	259	260	94	166
1889	225	224	83	141

Very few candidates failed entirely in the examination.

The Examiner reports that the character of the work done shows a considerable advance in the method of preparation, and a general improvement in the knowledge of the requirements of the Society in the matter of music.

XVI.—Commercial Examinations.

It was announced in last year's report that a scheme of examinations in Practical Commercial Knowledge had been prepared, the proposal being, in the first instance, to examine candidates in two divisions only—the Commerce of Food and the Commerce of Clothing. Candidates for these examinations will be required to have passed certain preliminary tests, and they will then be expected to answer questions as to sources of supply of the various products, the countries producing them, their nature, methods of testing, substances used in adulteration, values, methods of importation, cost and methods of transport, foreign markets, discounts, trade allowances, shipping insurance, customs duties, &c.

The Clothworkers' Company very liberally made an offer of two travelling scholarships of Fifty Pounds each for competition among candidates obtaining First-class Certificates in this subject, as well as a First-class Certificate in French or German, and one other European language, preferably Spanish or Italian.

The Council regret that no candidates have as yet offered themselves. They, however, purpose to renew the proposal next year, in the hope that by that time suitable candidates may have prepared themselves and will come forward.

Full details will be found in the Programme of Examinations for the current and for the coming year.

XVII.—Prizes for Drawing.

Members will remember that Mr. T. R. Ablett read a paper on "Drawing, a means of Education," at an ordinary meeting of the Society, on May 2nd, 1888. Since then the Drawing Society of Great Britain and Ireland has been founded, with the object of encouraging the teaching of drawing in secondary schools, and the Council have decided, provided sufficiently good works are forthcoming, to give twelve bronze medals to be awarded by the Drawing Society—two in each of the following divisions of the Annual Exhibition proposed to be held by that Society:—1 technical, 2 scientific, 3 educational, 4 artistic, 5 decorative, 6 miscellaneous.

XVIII.—National Co-operative Exhibition.

In last year's report the members were informed that the Council had offered Society's bronze medals in each of the twenty classes into which the National Co-operative Association proposed to divide their Exhibition. The Exhibition was held at the Crystal Palace in August last, and the Judges awarded a bronze medal in each of the following classes:—(1) Engineering, (2) Art Metal Work, (3) General Metal Work, (4) Joinery, (5) Cabinet-making, (6) Printing and Lithography, (7) Bookbinding, (8) Watchmaking and Jewellery, (9) House Decorating, (10) Stone, Wood, and other Carving, (11) Leather-work, (12) Boot-making, (13) Tailoring, (14) Basket-work.*

The Exhibition was well attended, and gave satisfaction to the promoters.

* The list of awards is printed in the *Journal*, August 31st, 1888, vol. xxxvi., p. 1017.

XIX.—Conversazione.

The Conversazione for the present year, as members are aware, will be held on Friday next, the 28th instant, the arrangements being precisely similar to those adopted last year. While fully appreciating the value of the assistance they have for so many years past received from the Lords of the Committee of Council on Education, by the loan of the South Kensington Museum, the Council regret that they have not succeeded in finding any other suitable building in London where the Society's Conversazione could be held. The conditions under which the loan of the Museum is now granted preclude the sale of tickets to the members for their friends; and as the Council feel that only a very limited sum can be spent for such a purpose out of the Society's funds, they are of necessity obliged to restrict the expenditure within very narrow dimensions.

XX.—Paris Exhibition.

When, in February, 1888, a committee was formed under the chairmanship of the then Lord Mayor, Mr. (now Sir Polydore) de Keyser, for the purpose of organising a British Section for the Paris Exhibition, that committee addressed an application to the Society's Council, asking that the Secretary of the Society might be allowed to act also as one of the secretaries to the Paris Exhibition Committee. The application was at once granted, and since that date Mr. Wood has been acting as secretary for the British Section of the Exhibition. In the meantime a portion of his duties have been most efficiently conducted by Mr. Wheatley, the Assistant-Secretary of the Society. The Council believe that it was desirable that an unofficial connection of this sort should be established between the present Exhibition and the Society of Arts, which in past years has been so closely associated with all the great International Exhibitions. They are also pleased to be able to put on record that the efforts of the British Committee have met with a very considerable amount of success, and that owing to their labours the British Section in Paris is by no means unworthy of its predecessors in previous Exhibitions.

XXI.—Obituary.

The Society has sustained some heavy losses by death in the past year, and obituary notices of the more prominent of the members who have died during 1888-89 will be found in the columns of the *Journal*. Mr. W. G. Pedder, late Revenue Secretary to the India-office, was an active member of the Society and of the Council until 1886, when he resigned his seat on the Council in consequence of ill-health. Mr. Warren de la Rue, F.R.S., the eminent chemist and astronomer, was a member of the Council from 1852 to 1855. The Duke of Buckingham and Chandos, K.G., was a member of the Society of nearly thirty years' standing, and in 1885 he became a Vice-President. Sir John Henry Brand, G.C.M.G., President of the Orange Free State, was elected a member of the Society in 1875. Sir Henry A. Hunt, C.B., was for many years connected with the Society. Mr. W. Eassie, the sanitary engineer, was a frequent speaker at the sanitary conferences held a few years ago, and he also read some valuable papers at the evening meetings. Colonel F. Beaumont frequently joined in the discussions, and also read a paper on his compressed-air locomotive for tramways, &c. Mr. John Frederic La Trobe Bateman, F.R.S., the eminent civil engineer, who supplied Glasgow with pure water from Loch Katrine, and some years ago projected a scheme for bringing water to London from Bala Lake, was connected with the Society since 1860. Mr. Edwin Bryan Donkin, the eminent amateur photographer, who was lost while travelling amongst the heights of the Caucasus, was another member of the Society whose death was very widely deplored. Among the distinguished men who have received the Albert Medal, the honoured name of Mons. Michel Chevreul must be mentioned as one of those who have died since the last Annual Meeting; and Captain Stab, one of the honorary corresponding members who at various times contributed important information to the *Journal* on subjects which came under his notice as Consul at Smyrna, must be added to this list of the Society's losses by death.

XXII.—New Council.

The Vice-Presidents retiring this year by seniority are Sir Edward Birkbeck, Professor Dewar, Sir Frederick Leighton, Sir Henry Ponsonby; while the members of Council whose period of service comes to an end are Mr. W. Anderson, Mr. W. H. Barlow, Sir Myles Fenton, and Colonel Hamilton. In their place the Council propose for election as Vice-Presidents Mr. Anderson (on his retirement as a member of Council), Sir Douglas

Galton, Lord Alfred Churchill, and Mr. J. Staats Forbes. Sir Douglas Galton and Lord Alfred Churchill have both in former years served for long periods on the Council, and both of them have held the office of Chairman of Council. Mr. Forbes, though he has never before served on the Council, is a member of the Society of old standing, and one whose long experience, especially of railway matters, cannot fail to be of great service. The members of the Society whose names are suggested for election as members of the Council are Mr. Preece and Mr. Matthey, who retired a year ago from seniority, having served many years on the Council; Professor Kennedy, who has lately rendered special services to the Society in connection with the Motor Trials, and Mr. C. M. Kennedy, C.B., of the Foreign Office. Neither of the two last-named have before been on the Council.

XXIII.—List of Members.

The total number of life members, subscribing members, and institutions in union which subscribe to the Society from their own funds, is now 3,406. The numbers last year were 3,473. During the year 1888-9, 320 members have been removed from the list by death or resignation. During the same period 253 have been elected.

XXIV.—Finance.

The financial condition of the Society is fully shown in the Treasurer's Statement, which, according to the provisions of the Byelaws, was published in the last number of the Society's *Journal*. Most of the items refer to usual charges of expenditure, not varying greatly in successive years. The charge of £683 for the motor competition is, of course, a special one. Of this amount only £483 is really chargeable to the Society's funds, £200 (as shown in the Financial Statement of this and last year) having been received as fees. The Society's invested funds now amount to £12,384, its available assets to £17,098, against which only liabilities of £1,237 are to be set. In consequence of the Government of India having taken over the Oude and Rohilkund Railway, the shareholders in the company were paid off, and it became necessary to re-invest the sum of £2,695 received for the Society's shares. This amount, together with a sum of £480 of the Society's funds, was invested in the purchase of freehold groundrents in the Tyssen-Amherst Estate, Hackney.

The Chairman, in moving the adoption of the Council's Report, said that he wished particularly to congratulate the Society on the part it had taken in the formation of the British Section of the Paris Exhibition, and he thought that the success of that Section, through the labours of the Secretary, reflected the greatest credit upon the Society. He was glad, as one long connected with exhibitions, to have the opportunity of testifying to Mr. Wood's most admirable arrangements.

Mr. Hyde Clarke seconded the adoption of the Report, and expressed his pleasure that the Council had under consideration the discontinuance of the alternate award of the Swiney Prize to General Jurisprudence and Medical Jurisprudence. The latter was an unfortunate technical term, as the subject of medical law was not jurisprudence at all. He considered the successful carrying out of the Motor Trials as adding one more to the many public services performed by the Society during the long period of its existence. He wished the funds of the Society were larger, so that more could be done in this way.

After some discussion on the time allowed for keeping the ballot open, it was moved by Mr. Francis Cobb, Treasurer of the Society, and seconded by Sir George Birdwood, K.C.I.E., that this general meeting is of opinion that the time which the ballot at present takes of one hour is out of all proportion to the requirements of the present day, and this meeting suggests to the Council that they should take such steps as shall enable the next general meeting to reduce the time for ballotting at annual general meetings to not less than thirty minutes.

The meeting, on the motion of Mr. Francis Cobb, requested the Chairman to express to the Duke of Abercorn, Chairman of the Council, their regret at his absence, and sympathy with him in his illness.

Mr. J. Eastty wished to draw the attention of the Council to means for the making the Reading-room more useful to the members, and he suggested that the daily newspapers and the best magazines should be supplied.

The ballot having remained open for one hour, and the Scrutineers having reported, the Chairman declared that the following had been elected to fill the several offices. The names in *italics* are those of members who have not, during the past year, filled the office to which they have been elected.

President.

H.R.H. the Prince of Wales, K.G.

Vice-Presidents.

H.R.H. the Duke of Edinburgh, K.G.	H.R.H. Prince Albert Victor of Wales, K.G.

Sir Frederick Abel, C.B., D.C.L., LL.D., F.R.S.	Sir Philip Cunliffe-Owen, K.C.B., K.C.M.G., C.I.E.
Duke of Abercorn, C.B.	Major-General J. F. D. Donnelly, C.B.
William Anderson, M.Inst.C.E.	*James Staats Forbes.*
The Attorney-General, M.P.	*Sir Douglas Galton, K.C.B., D.C.L., F.R.S.*
Sir Francis Dillon Bell, K.C.M.G., C.B.	Thomas Hawksley, F.R.S.
Sir Frederick Bramwell, Bart., D.C.L., F.R.S.	Sir Villiers Lister, K.C.M.G.
Colonel Sir Owen Tudor Burne, K.C.S.I., C.I.E.	Duke of Manchester, K.P.
Alfred Carpmael.	Alderman Sir Polydore de Keyser.
R. Brudenell Carter, F.R.C.S.	Sir Robert Rawlinson, K.C.B.
Lord Alfred S. Churchill.	Lord Thurlow, F.R.S.
Sir Daniel Cooper, Bart., G.C.M.G.	

Ordinary Members of Council.

Benjamin Baker, M.Inst. C.E.	*Charles Malcolm Kennedy, C.B.*
Sir George Birdwood K.C.I.E., C.S.I., M.D., LL.D.	John Biddulph Martin.
Michael Carteighe.	*George Matthey, F.R.S.*
Sir Juland Danvers, K.C.S.I.	*William Henry Preece, F.R.S.*
Sir Henry Doulton.	Edward C. Robins, F.S.A.
Prof. Alexander B. W. Kennedy, F.R.S.	Lord Sudeley, F.R.S.

Treasurers.

B. Francis Cobb.	Sir Owen Roberts, M.A., F.S.A.

Secretary.
H. Trueman Wood, M.A.

The Chairman then moved the usual vote of thanks to the Scrutineers, which was carried unanimously.

A vote of thanks to the Chairman and Council was moved by Mr. Eastty.

In seconding the motion, Dr. Pankhurst alluded to the proposed action of the London County Council on many of the subjects in which the Society of Arts were interested. He thought that much public good might accrue by combined action in the future.

Sir George Birdwood thought that Dr. Pankhurst's suggestion was a very good one, and he hoped that the question of overhead wires and the disfigurement of the London streets by advertisements might be considered.

The Chairman recommended that the special attention of the County Council should be drawn to the many papers dealing with the subjects of the work of the Council and its Committees which had been read before the Society in past years.

The Chairman then moved a vote of thanks to the Secretary and other officers of the Society. This was seconded by Mr. W. Lascelles Scott, and the compliment was acknowledged by the Secretary.

Sir Owen Tudor Burne, K.C.S.I., proposed a cordial vote of thanks to the Chairman, which was seconded by Mr. E. C. Robins.

Correspondence.

SCIENCE OF VENTILATION AS APPLIED TO THE INTERIOR OF BUILDINGS.

Mr. W. P. Buchan writes:—As to Mr. Hoey's statement, on page 662, that "at the conclusion of the debate before the Philosophical Society of Glasgow I gave an incontrovertible reason why I cannot enter upon discussion with him (Mr. Buchan)," I beg to observe that neither I nor other persons I have spoken to who were present heard him saying anything to that effect. I invite him, therefore, to state what this supposed "incontrovertible reason" was or is, so that its value may be tested.

General Notes.

Wine Production in the Herzegovina.—Grapes are grown in many parts of the Herzegovina, but principally in the valleys of the Narenta and Rama. Consul Freeman says that the total annual produce may be estimated at about 25,000,000 okes (613,840 cwts.). Fairly good wine is made, and it is strong and generally sweet like the Dalmatian wines. There used to be a larger exportation of grapes from the Herzegovina to Austria for the manufacture of wine, but since the Treaty of Commerce between Austria and Italy, by which Italian wines only pay three florins per hectolitre on entering Austria-Hungary, the exportation has fallen off. The past vintage was very abundant, and grapes were sold at 6 to 7 kreutzers ($1\frac{1}{5}$d. to $2\frac{2}{5}$d.) per oke ($2\frac{3}{4}$ lbs.), against 13 to 14 kreutzers ($2\frac{3}{5}$d. to $4\frac{1}{5}$d.) in the year 1887. The local government, with a view to the improvement of the cultivation of the vine and of the manufacture of wine, is laying out a model vineyard at Buna, near Mostar, about nineteen acres and three quarters in extent, and of which about three acres and a half will be planted in the coming spring.

Journal of the Society of Arts.

No. 1,911. Vol. XXXVII.

FRIDAY, JULY 5, 1889.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CHAIRMANSHIP OF COUNCIL.

On Monday last, 1st inst., at their first meeting after the annual election, the Council elected the Duke of Abercorn, C.B., as Chairman of Council, and Sir Frederick Bramwell, Bart., D.C.L., F.R.S., as Deputy-Chairman, for the ensuing year, The various committees were also re-appointed.

INDIAN AND FOREIGN SECTIONS.

The Council have determined that next Session the meetings of the Indian and of the Foreign and Colonial Sections shall be held in the afternoon from 5 to 6.30 p.m., instead of, as hitherto, in the evening.

Proceedings of the Society.

CONVERSAZIONE.

The Society's *Conversazione* was held at the South Kensington Museum (by permission of the Lords of the Committee of Council on Education), on Friday evening last, 28th inst.

The Courts and Corridors of the Ground Floors, and the Galleries containing the Raphael Cartoons, Sheepshanks Collection, the William Smith Collection of Water Colour Drawings, the Dyce and Foster Pictures, and the "Chantrey Bequest" were open.

The Reception was held in the West Architectural Court by Sir Frederick Bramwell, Bart., D.C.L., F.R.S., Deputy Chairman (the Duke of Abercorn, C.B., Chairman, being unavoidably absent in consequence of illness), and the following Vice-Presidents and Members of Council:—Mr. William Anderson, The Attorney-General, M.P., Sir Edward Birkbeck, Bart., M.P., Colonel Sir Owen Tudor Burne, K.C.S.I., Mr. Alfred Carpmael, Mr. Francis Cobb, Sir Philip Cunliffe Owen, K.C.B., K.C.M.G., Sir Juland Danvers, K.C.S.I., General Donnelly, C.B., Sir Henry Doulton, Mr. Thomas Hawksley, F.R.S., Mr. J. Biddulph Martin, Sir Robert Rawlinson, K.C.B., Sir Owen Roberts, and Mr. E. C. Robins.

Promenade concerts were given by the Band of the Royal Artillery (Conductor Cav. L. Zaverthal) in the North Court, and by the Band of the Scots Guards (Conductor Mr. Edward Holland) in the Quadrangle of the Museum.

BAND OF THE ROYAL ARTILLERY.

1. March ... "Oesterreicher Landsturm" ... Schrammel.
2. Overture .... "Fra Diavolo" .... Auber.
3. Valse .. .. "Wiener Blut" .... Strauss.
4. Selection .... "Rigoletto" .... Verdi.
5. Song ...... "For Ever and for Ever" .. .. Tosti.
   (Cornet Solo,) Sergeant Jenner.
6. Pizzicato .... "Sylvia" .... Delibès.
7. Violin Solo ... "Romance et Bolero" .... Dancla.
   Musician Brown.
8. Selection .... "Carmen" .... Bizet.
9. Valse .... "Doctrinen" .... Strauss.
10. Song .... "Adieu!" ... . Schubert.
   (Cornet Solo.) Sergeant Jenner.
11. March .... "The Turkish Patrol" .... Michaelis.
12. Selection ... .. "Gems of England" .. .. Basquit.

BAND OF H.M. SCOTS GUARDS.

1. Overture .... "Le Roi d'Yvetot"........... Adam.
2. Selection from Schumann's Songs.
3. Valse...... . ..."Das Tanzende Berlin" ...... Steffens.
4. Selection ...."Roméo et Juliette" .... Gounod.
5. Gavotte ...."Klange vom Rhein" .... Latan.
6. Selection...... "Yeomen of the Guard" ...... Sullivan.
7. Song..................... "Nazareth"........ . ... Gounod.
8. Descriptive Battle Music
   "Battalia de los Castillejos"...... Marin.
9. Patrol March "Die Wachtparade kommt" Eilenberg.
10. Selection .... "Paul Jones" .... Planquette.
11. Valse .... "Wiener Bonbons" ...... Strauss.
12. Scotch Selection... "Robert Bruce" ... . —
13. Marche Francaise ... "Père la Victoire" ... Gane.
14. Galop Militaire ... "Pleine Carrière" ...... Bohm.

God Save the Queen.

A selection of glees, madrigals, and part-songs was given by Mr. Edward Plater's Glee Union (Mr. Jas. A. Brown, Mr. Edward Plater, Mr. Albert James, Mr. Frederick Bevan) in the Lecture Theatre.

PART I.

(At 9 p.m.)

Madrigal .... "Down in a flow'ry vale".. Festa (1541).
Part Song................ "Lovely Night"......... Chwatal.
Glee ...."Haste, ye soft gales" ... Martin.
Glee .... "The Sycamore shade"... Sir John Goss.
Part Song ...."The Hemlock Tree" ... Hatton.
Part Song ... . "Banish, O Maiden" ... Lorenz.

PART II.
(At 10 p.m.)

Madrigal .... "Come, let us join" .... Beale.
Glee .... "How sweet, how fresh" .. .. Paxton.
Part Song . ... "Beware" .... Hatton.
Glee .... "In a cell or cavern deep" .... J. Parry.
Catch "Would you know my Celia's charms" Webbe.

PART III.
(At 11 p.m.)

Glee .... "Tell me, babbling Echo" .... Paxton.
Part Song ... "Wanderer's Night Song" ...... Schneider.
Glee .... "When the wind blows" .... Horsley.
Glee .... "By Celia's arbour" .... Horsley.
Part Song .... "Littel Byngo" ... . Mackenzie.

The number of visitors attending the *Conversazione* was 2,204.

CANTOR LECTURES.

ENGRAVING IN WOOD.

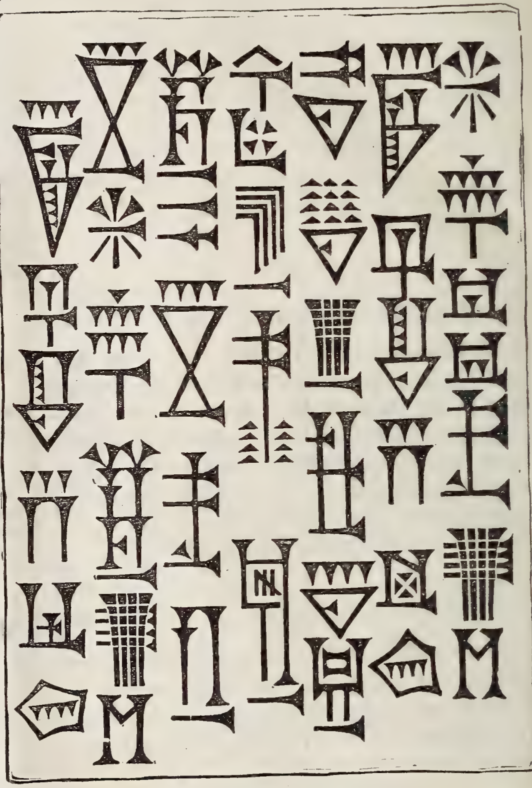
By W. J. Linton.

Lecture I.—Delivered February 11*th*, 1889.

The lecturer began by exhibiting enlarged representations of a brick from Babylon and an Egyptian stamp, the inscription on the first being shown as an instance of engraving in relief, the spaces between the characters cut away, and the indentations or points made in the material in the brick as would be on paper; the second showing an intaglio, the characters cut or hollowed beneath the surface. The two were given as indicating the two methods of engraving possible of execution either in wood or metal. The difference between the printing from wood and the printing from metal was explained to be that from metal the impression could be taken either by inking the surface or by filling the incised lines with ink, and printing from them after cleaning the surface of the plate; while from wood it could only be taken from the surface, as the wood, absorbing the ink, could not be kept clean. Therefore the peculiar and distinguishing character of wood engraving is that it must be printed from the surface.

These two engravings (the brick and stamp) proved the antiquity of the art, though neither Babylon nor Egypt might claim the invention. The first notch cut in a tree disclosed the secret of intaglio engraving, and from intaglio to cutting for relief was an easy transition. The practice of some sort of engraving appears also to have been universal—found in the South Sea Islands when first visited by Captain Cook, used by the Greeks and Romans, and from remote time in China, whence some have thought it was brought to Europe. There seems, however, no need of such borrowing. In Europe its first appearance—passing over a discredited story of some earlier Italian work—was in Germany, at the close of the 14th or beginning of the 15th century. The first

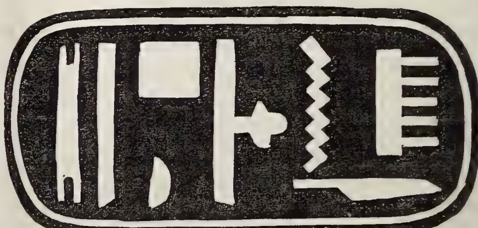
FIG. 1.



BABYLONIAN BRICK.

known print with a date is a St. Christopher of 1423, a coloured print some 11 by 8 inches, which is in the possession of Earl Spencer (Fig. 3),

FIG. 2.



EGYPTIAN STAMP.

one of a number of prints called *Helgen*, or saint pictures, distributed by the monks in Suabia and neighbouring districts of Germany. The *Helgen* the lecturer considered to have

been the first products of wood engraving, though playing-cards, produced about the same period, are thought by others to have preceded them.

Until 1844 the St. Christopher was held as beyond dispute the earliest dated of these engravings; but in 1844 an architect of Malines discovered in an old coffer in which the city records had been kept, a print with a supposed date of 1418; a print rather larger than the St. Christopher, now in the Royal Library at Brussels. The lecturer doubted the validity of this date, not satisfied with the evidence of the condition of the print when found, and also judging the character of the drawing to be of a later period. Other *Helgen* in the possession of Earl Spencer (the Salutation of the Virgin and a St. Bridget) were referred to, and a fifth at Berlin; these five as the most notable of such early works.

From single points the advance was to connected series, forming books known as

FIG. 3.

ST. CHRISTOPHER.

"block" books, because before the invention of movable types, text and picture were both cut on the same piece, or joined pieces, of wood. They are called block books incorrectly, being always upon planks, slices of wood sawn lengthwise with the grain or fibre. The earliest known of these books is the "Apocalypsis," a book of fifty leaves, illustrating the Revelation of St John. On each leaf the unbacked page has a single cut about ten inches high, divided into two scenes or subjects, an upper and a lower, outlined figures and passages of Scripture, rude in drawing, and rudely cut, but yet with no little power in the archaic treatment of the work.

A second book is the "Book of Canticles," Solomon's song, in a series of sixteen cuts, nearly the size of those of the "Apocalypsis," like that, having two subjects on each leaf, illustrating the love of Christ for his Church,

an adaptation of "Solomon's Song to his Beloved." Texts are interspersed among the figures, always on scrolls. The work here is better drawn and more delicately cut than that of the "Apocalypsis."

A third of these famous books is the "Biblia Pauperum" (Book of the Poor Preachers), with forty unbacked pages about ten inches in height, on each page three cuts across the middle, the central one from the New Testament, and the side pictures from the Old Testament, referring to or intended as types of the central one. Above and below these subjects, in a sort of architectural border, are texts and rhyming Latin verses, and portraits of holy men and patriarchs. The book was evidently intended as a manual or text-book for the preaching friars, who might also show the pictures to their audience. In the first edition of this often copied book the engravings are remarkably good.

A fourth block book of equal excellence is the "Ars Moriendi" (Art of Dying), eleven smaller page designs, with corresponding number of pages of text and two of introduction. The designs represent the temptations to which a dying man is exposed, shown in alternate pictures of Satanic instigation by a lot of grotesque devils, and angel visitants answering and repelling the same. The five temptations are to Unbelief, Despair, Impatience, Vain Glory, and Avarice. In the eleventh design we have the final death scene, the sinner saved. These block books were in all probability produced during the half-century following the St. Christopher time, 1423, the "Canticles" being Flemish work, the other three German. Some few other block books, besides various editions of these described, are also known, but they have no engraving worthy to command our attention.

As the use of moveable types became general the block book was discontinued. Picture-books were still in request, but the engravings were now to be looked upon, as in the present day, chiefly as additions or supplements to the works which they illustrated or embellished. Earliest of such works, and important as marking the passage from the block book to the illustrated book of to-day, is the "Speculum Humanæ Salvationis" (The Mirror of Human Salvation), a book of fifty-eight pages or leaves, with unbacked pictures of the same character as the older block books, but with texts from type on half of the pages below the cuts, each cut divided into subjects, the two occupying the full width of the page. The cuts of all these books, and the *Helgen* before them, although varying in excellence, are all of one identical character as regards the engraving, not executed with a graver, as our modern wood engravings are, but invariably cut with a knife, the drawings made line for line on planks of pear-tree or other soft, white wood, the engraver's business being merely to cut and clear away the white wood between the lines, leaving all lines of the drawing intact. Crossed lines were avoided to save the engraver's trouble, and not needed, as the cuts were meant to be coloured.

Engraving with effect may be said to have begun with the great German painter and draftsman on wood, Albert Dürer. He saw the

FIG. 4.

THE WOOD ENGRAVER.

advantage of completing his picture with thorough consideration of light and shade, so making a single gradated colour take the place of the old polychrome. The older coloured prints may be looked upon as cheap imitations of the illuminated manuscripts. Dürer established engraving on its own merits, without need of colours. Passing in brief review the political and religious circumstances of the period in which Dürer lived (the time between Huss and Luther), and showing how these circumstances affected the artist, the lecturer proceeded to describe his works, from

his first serial publication, the "Apocalypse," issued in 1498—fifteen cuts fifteen inches high and eleven inches wide—to the two series representing the sufferings of Christ, the "Greater" and "Smaller Passion," and the "Life of the Virgin." The great influence of Dürer on wood engraving was stated to be owing to the remarkable decision and clearness of his drawing, notwithstanding its elaboration, which afforded excellent practice for the engraver. The lecturer absolutely denied the likelihood of the actual engraving being done by Dürer, the very perfectness of it proving that it could only have been done by the more practised hand of a regular workman. Also, the time required for his numerous other occupations precluded any leisure for such employment. Of the "Greater Passion," twelve cuts of the same size as those of his "Apocalypse," seven appear to have immediately followed the production of that, the other five not done until 1510. The "Smaller Passion," thirty-seven cuts about six inches by four, appeared in 1511. Of these, thirty-three of the original blocks are in the British Museum. The "Life of the Virgin," with twenty cuts about twelve inches by eight, was also brought out in 1511. These four magnificent series were produced at Dürer's own cost, and sold by him as occasion offered.

[Enlarged representations of the *Helgen*, the block books, and Dürer's works were exhibited on the screen during the lecture, which closed with a somewhat reduced representation of Dürer's "Arch of Maximilian" (the actual size of which is ten feet and a half in height and nine feet in width), and with some account of Jerome Andreæ, of Nurnberg, the chief of the Dürer engravers.]

Lecture II.—Delivered February 18th, 1889.

The second lecture began with the repeated exhibition of Dürer's "Arch," and with notice of that and other works composing with it what is known as the "Maximilian Triumph;" Dürer's and Burgkmair's "Procession" (principally the work of Burgkmair), and Durer's "Car" as part of that. The "Procession" "in praise and for perpetual commemoration of the noble pursuits and glorious victories of the most serene and very illustrious Prince and Lord Maximilian, Roman Emperor and Chief of Christendom, King and Heir of Seven Christian Kingdoms," &c., &c., was briefly described; a series of figures of great variety, huntsmen, court officials, knights, and princes, on horseback, on foot, and in cars, with trophies and allegorical designs, admirably drawn, and well engraved, on planks about 18 inches high, the whole series reaching to a length of nearly 200 feet. The "Procession" was the work of about a dozen engravers, so many names being cut on the backs of the planks, apparently under the direction of Jost de Necker, a master wood-engraver at Augsburg. The imperial car, with its twelve led horses, intended to have its place in the pageant, was designed by Dürer, and engraved by Jerome of Nurnberg, before spoken of.

Passing from Dürer, the lecturer called attention to the crowning achievement of knife work in wood, the cuts for Holbein's "Dance of Death," first published in 1538, at

FIG. 5.

Der Richter.

HOLBEIN'S "DANCE OF DEATH."

Lyons; forty-one cuts in this first edition, seventeen more (not all by Holbein) added in later issues. They were engraved (the forty-one), most probably, at Basle, between 1526 and 1530, by Hanns Lutzelburger, of whom little else is known beyond his work here. Why these cuts should be highly valued, the lecturer endeavoured to explain. Truly they are only what is called fac simile, not much more than outline, drawn line for line on the wood, with little attempt at effect, no care for tone, and with none of the fineness or closeness of line ignorantly admired in modern work. They are "only fac simile," but what is that? We call fac-simile that which fairly

represents an original, rendering line for line. Such is the work we see in these knife-cut engravings by Lutzelburger, and also in work cut with a graver in both the loose and the more elaborately systematised lines in publications of our own day, in *Punch* for instance. But is merely line for line to be called facsimile? Speaking strictly, in things of art it is not. "Near enough" has no place in art. To be true fac-simile, the engraving of a drawing must be not only a line always where a line was drawn, an engraved line instead of a drawn line, but the line must be a faithful and exact repetition of the drawn line's expression in all its subtlety and variety. It must have every quality of the original drawn line, not a mere mechanical exactness, but an artistic exactness beyond any possibility of mere unartistic mechanism. Of course if the drawn line is in itself inexpressive, if it has no subtlety or variety, there is none for the engraver to render. But when the drawn line has expression, it needs the artistic perception and rendering which alone can entitle it to be called fac-simile. It is for this perfectness that Lutzelburger's rendering of Holbein deserves our special admiration. It is, indeed, what Holbein himself would have done had he possessed Lutzelburger's skill with the knife. It is as if the draftsman had guided the engraver's hand. In all he knew of engraving in wood, the lecturer recognised nothing equal to these cuts, except some little pen and ink sketches by Stothard, in 1812 (for an edition of Rogers's poems), engraved by Luke Clennell, the most accomplished of Bewick's pupils and also a painter of considerable merit. Admiration for these cuts was of course simply due to fac-simile work. The rendering of a drawing in which the choice of lines is left entirely to the engraver is to be considered as almost a distinct art.

Two cuts much enlarged were here shown, both drawn with pen and ink in precisely the same style and manner, one cut by Clennell, the other by an inferior hand; in Clennell's the draughtsman's rich full touch was preserved; the other was meagre and inexpressive, not a single line lost, but the form and expression of the line quite gone. The perception of this distinction the lecturer insisted upon as the only ground of any true criticism or judgment of engraving.

Leaving fac-simile, the early manner of wood engraving, the lecturer came to the later and more artistic process of engraving from a drawing without lines, a drawing which might be made with charcoal or washes of colour, forms and effect (light and shadow) given by the draughtsman, but much of both form and effect, and the preservation of distances and textures, to be expressed by lines of the engraver's own invention—a new and distinct phase of the art of wood-engraving—known as the white-line process, because, while in all the old knife work every line was a line left on the surface to be printed black, in this new method the incisions of the graver, what might be called the really expressive lines, are all white. That is to say, the white lines give the drawing. The new art began when men accustomed to work in metal found that they could use the graver on the end, that is on a section, of boxwood, instead of having only the knife to work with on the plank. All old work in wood, it must be repeated, was done with the knife, because the wood was used in planks or boards, and not in rounds. The wood used was of pear-tree or some other soft white wood, easily drawn on and easily cut with a knife. Of course, it was not enough to make a single incision: that merely pierced the wood. A second cut was needed to take out the piece, both cuts slanting to meet each other. Imagine that you have a square drawn on a piece of wood, four lines meeting at the corners of the square. If not a very small square the engraver would need two cuts of his knife for each line of the square, so only outlining the inner sides of the lines. If the square was very small, four cuts might be enough, their slanting meeting in the middle, and lifting out the whole piece. If not so small as this, eight cuts would be required, and, any way, eight more for the outsides. Draw two lines crossing two lines, and extending beyond the square formed by ther interstices, and you will need forty-eight cuts with your knife only to outline your drawing; there will be wood to clear away besides, for which, if very large, you may use a gouge. This may show the tedious method of engraving that great work of Dürer, and the delicacy required for the cuts of the "Dance of Death." There was no other way of doing them on the plank. A graver, which is a miniature plough, lozenge or diamond shaped and solid, would cut a line cleanly enough with the grain of the wood, but against the grain would not cut, but only break the wood, throwing up the broken wood on each side of the furrow as a plough throws up the clods of earth. The graver only came into use on wood when it was thought of

cutting boxwood in rounds, so that the graver could be used without hindrance of the grain. This does not seem to have been found out before the beginning of the last century; the exact date of its first use is very uncertain.

The use of the graver gave opportunity for a new and more artistic employment of our art. The engraver might now choose his own lines, literally drawing them with his graver whether to express form or to give gradations of colour. This is what we call white-line work. No need now of double cutting to get out the wood; each line is a single furrow of the steel plough, a process fairly to be called art when the ploughman works not only with a graver but with the guiding hand of intelligence. This is the work which made Thomas Bewick of Newcastle famous. He has been wrongly credited with the invention of the method; he certainly was not the first to use it in wood, and in soft metal the unknown engraver of the cuts in Croxall's "Æsop" preceded him by half a century. Still the palmy days of good white work in wood are to be distinguished as the Bewick period. But even in Bewick's time there was a departure from it. His contemporary, Branston, aimed rather at imitations of copper, and when Thurston, a copper engraver, took to drawing on wood, the free line of Bewick began to be abandoned. Not but that Branston was an able engraver, and his greatest pupil, John Thompson, surely ranks as chief in his art; but only as engraver. The difference between his work and Bewick's consists in this, Bewick drew his own lines with the graver, not having lines drawn for him; Thompson had lines laid down by Thurston, though not always to be followed servilely. Thurston's drawing also would not be altogether in lines, and even the lines would be at the judgment of the engraver. But it was no longer pure graver-work of Bewick, or of his greatest pupil, Clennell. His (Clennell's) painter-like superiority might be forgotten with so great a master of beautiful line as Thurston was, and so accomplished an engraver as Thompson. No less was their work a departure from the true province of engraving in wood, the drawing every line with the graver. Harvey departed yet further in an ambitious attempt to rival the peculiar excellences of copper. His "Assassination of Dentatus," the most daring of works in wood, is a magnificent failure. His drawings (for he gave up engraving), graceful and able as they were, had in them a certain lady-like weakness, to render which required little beyond delicacy and refinement of tone; so drawing down the art from the high level of Thurston's and Thompson's work. Thurston taught the copying of the power of copper; Harvey led to imitation of its weakness. The engraver, not necessarily an artist as his drawings were made for him, thenceforth prided himself on polish, and fineness (closeness) of line enfeebled his hand, until he lost even a sense of the value of lines either for strength or beauty. The very critic became so accustomed to the meaningless monotony of wood engraving, that when he praised he only by his praise confirmed the degradation.

Of white-line work there are two sorts—the intelligent and the unintelligent; the one with purposeful lines, the other with any lines which give colour and fill the prescribed space, such lines being crowded together to give what is called fineness, and so hiding their imbecility. No such work, however pleasant the appearance and general effect of the picture, can be called good; and certain appropriateness and beauty of line—on the principle that in a work of art everything should be artistic—are necessary to constitute a fine engraving. Art and mechanism are not the same, though the line between them may not be always clear. Mechanism needs only hands, art needs brains also; art is expressive, mechanism inexpressive. Lines cut with design have art in them; cut without a sense of drawing, without consciousness of their meaning, they are only mechanical. A good engraving can be made from a poor drawing; also a poor engraver can make a passable cut from a good drawing. Let him be moderately faithful to colour, and though sky, and ground, and water be only distinguishable by position, one most conventional line serving for everything, the cut to the untaught observer may look like fine work. The public cares for little more, not knowing what more is wanted.

What has been called a new departure in America is to be condemned for its want of art. It is only a very marvellous mechanism; colour is well kept, fineness, thinness of line is remarkable, though not finer than of old; the often needless, sometimes unhappy, minuteness is astonishing. But in very few cuts are there any lines of beauty, of fitness, giving sign of intelligence, or showing that the engraver had brains; that he could have understood the forms he was engraving; that he had any knowledge of perspective, or any perception of differences of substance. Distant objects

come on the same plane as the foreground, and for any distinction of treatment may be ground, or water, or folds of drapery. The lines throughout are laid with utter disregard of what is to be represented by them, in seeming ignorance or wilful eccentric rejection of the laws of linear beauty. Objects stick together, everything is muddled and confused. As clever imitations of photographs, but not so good, they may be tolerated; but for all that engraving in itself is valuable they are nought.

Colour and tone may be excepted from so sweeping a condemnation, but colour and tone —not better than in old days—are not all that is wanted in engraving. Not underrating their value, an intelligent and beautiful line must be insisted on as the primary essential of good engraving. It may be remarked that these same engravers in their portraits do care for this beauty of line, so condemning their departure elsewhere. To conclude, good line-engraving is the formation of a picture by fit lines—fit and beautiful.

[Enlarged examples of Bewick, Clennell, Nesbit, and Thompson were shown in the course of the lecture.]

Miscellaneous.

SCHOOL FOR MODERN ORIENTAL STUDIES.

A School for Modern Oriental Studies has been established by the Imperial Institute of the United Kingdom, the Colonies and India, in Union with University College and King's College, London, and the following is the official statement of the formation of the school:—

The commercial and official classes in the United Kingdom, whose pursuits entail either temporary residence in, or visits to Oriental countries, and communion or correspondence with the natives of those countries, have long experienced the want of facilities which might be afforded by a sufficiently comprehensive public institution, where a practical and colloquial acquaintance with the more important modern Oriental languages might be acquired.

In France, Germany, and Austria-Hungary, there exist institutions of magnitude and importance for affording instruction in the spoken and written Oriental dialects, and in matters relating to the history, commerce, and political economy of the countries in which those languages are spoken.

In France, the School of Living Oriental Languages, which was founded nearly 100 years ago, receives from the State the free use of a large building, and a grant of over £6,000 per annum; gratuitous instruction is there given in the chief modern Oriental languages, and a commercial section has recently been added to it by the Minister of Public Instruction.

The Imperial Oriental Academy of Vienna has long been of world-wide celebrity, and has greatly contributed to the extension of commerce in Austria-Hungary, whilst in Berlin, the Imperial German School of Living Oriental Languages, established a year ago upon a very important footing, has already received considerable development. This school is supported by an annual subvention of £3,600, and the tuition there is entirely gratuitous.

Although the scope of action of the Imperial Institute, as defined by its charter, does not embrace the exercise of actual educational functions, its governing body has considered that the creation and development of an organisation for providing, in the United Kingdom, the important aid to the official and commercial sections of the community which is furnished to continental nations by such establishments as above named, might prove a work of considerable utility.

There have existed at University College and at King's College, since their foundation, professorships of certain Oriental languages; the Indian School of University College on the one hand, and the Oriental section of King's College on the other, have accomplished useful work in the preparation of candidates for the Indian Civil Service and other Government departments, by affording facilities for the study of some of the Eastern languages.

The Committee of the Institute having met with a cordial response from the Councils of the two colleges to a proposal to consolidate the work of this nature now being performed there, and to bring it into harmonious working with a scheme for affording practical instruction in other important Oriental languages, now desire to direct attention to the results of a careful consideration of the whole subject by a special committee appointed by them for that purpose, which includes representatives of the Councils of University and King's Colleges, and of which the following are the members:—Sir Frederick Abel, C.B., D.C.L., D.Sc., F.R.S., Chairman; Col. Sir Edward Bradford, K.C.S.I.; Sir Francis Dillon Bell, K.C.M.G., C.B.; Col. Sir Charles Wilson, R.E., K.C.B., K.C.M.G.; Sir Thomas Wade, G.C.M.G., K.C.B.; Maj.-Gen. Sir Frederick Goldsmid, K.C.S.I., C.B.; Sir Philip Magnus; Major C. M. Watson, R.E., C.M.G. Nominated by the Council of University College—Sir George Young, Bart., LL.D.; Professor Henry Morley, LL.D. Nominated by the Council of King's College—The Rev. Henry Wace, D.D.; Professor R. K. Douglas.

Arrangements have been completed by this committee, and approved of by the governing bodies of

the Imperial Institute and of the two colleges, for the organisation of a school in London, designed both for giving instruction in modern Oriental languages, and also for the pursuit of studies relating to the history, literature, commercial and physical geography, political economy, and the natural and industrial resources of the countries and districts in which the various languages are used.

It is in contemplation to arrange for the delivery of special lectures, or courses of lectures, from time to time, in connection with the school, by experts or specialists, in any of the foregoing subjects.

This school will be carried on under the immediate direction of the committee above specified.

The classes which the "School of Modern Oriental Studies" comprises are divided under two heads.

Division I. includes classes for all Oriental languages especially required by students qualifying for examinations for the Indian Civil Service, the instruction being of the same character as that provided for some time past at University College and at King's College.

These classes will, from the commencement of the autumn term of 1889, be continued at University College, and will be conducted under regulations common to the other classes which combine with them to constitute the general school.

This division includes instruction in Sanscrit, Bengali, Hindi, Hindustani, Tamil, Telugu, Punjabi, Pali, Marathi, Gujarati, Arabic, and Persian.

Division II. consists mainly of classes for modern Oriental languages other than the Indian languages.

The courses of tuition will be of a practical rather than of an academic character; they will have particular reference to commercial and official requirements, and to the facilitation of colloquial intercourse with natives of Oriental countries.

It is in contemplation, so soon as the number of students warrants the expenditure, to secure the services of native readers and teachers of conversation in connection with the classes of this division.

The languages to be taught in Division II. comprise Colloquial Arabic, Modern Greek, Colloquial Persian, Russian, Turkish, Chinese, Burmese, Japanese, Malay, and Swaheli.

The classes under this division will be conducted at King's College, where arrangements will also be made for the establishment of evening classes.

There will be three terms, of about ten weeks, in each year, as follows:—Autumn term—commencing about the beginning of October; spring term—commencing about the middle of January; summer term—commencing early in May. The school will open with the autumn term of 1889.

A fee of three guineas per term will have to be paid, in advance, by each student for each language taken up for instruction. This payment will entitle the student to the use, within the colleges, of text-books, dictionaries, and works of reference required in connection with the particular language taught, and to the use of all the facilities which it is proposed to secure in the development of the school.

Accommodation will be provided to enable students to pursue their studies at hours when the classes are not held.

The libraries of both colleges will be open to students in any of the classes of the school during the usual hours of study.

Intending students should communicate with Sir Frederick Abel, C.B., F.R.S., the Organising Secretary, at the offices of the Imperial Institute, 1, Adam-street, Adelphi, London, W.C., where the registration of students will take place, and where all information regarding the school will be supplied.

FRUIT CANDYING INDUSTRY OF LEGHORN.

Her Majesty's Consul at Leghorn says that that city occupies the first place in Italy, and perhaps throughout the Mediterranean, for the preparation of the candied citron and orange peel, so largely used in all branches of confectionery—citron being brought for this purpose from Corsica, from Sicily, from Calabria and other southern provinces of Italy, from Tunis and Tripoli, and even from Morocco; while the candied peel of the fruit is exported to North America, to the United Kingdom, and to Hamburg for distribution throughout Germany. Sugar also is imported for the purpose of the manufacture from Egypt. The wood of the boxes in which the candied peel is packed comes from Trieste, and the immense earthenware vessels necessary for the saturation of the fruit in sugar syrup are made in the neighbourhood of Florence. The oranges imported into Leghorn, whether for consumption or for candying, are nearly all brought from the islands of Sicily, Sardinia, and Corsica. In all the countries contributing the raw fruit for this industry it is treated in the same manner for the over sea passage. The fruit is simply halved and placed in hogsheads or large casks filled with a fairly strong solution of brine, the fruit being halved merely to ensure thorough preservation of the rind by an equal saturation of the interior as well as the exterior surface. In these casks it arrives at the doors of the manufactory. The first process to which it is then subjected is the separation of the fruit from the rind. This is done by women, who, seated round a large vessel, take out the fruit, skilfully gouge out the inside with a few rapid motions of the forefinger and thumb, and throwing this aside, place the rind unbroken in a vessel alongside them. The rind is next carried to large casks filled with fresh cold water, in which it is immersed for between two and three days to rid it of the salt it has absorbed. When taken out of these casks, the rinds are boiled, with the double object of making them tender and of completely driving out any trace of salt that may still be left in them. For this purpose they are boiled

in a large copper cauldron, for a time varying from one to two hours, according to the quality of the fruit and the number of days it has been immersed in brine. When removed from this cauldron the peel should be quite free from any flavour of salt, and at the same time be sufficiently soft to absorb the sugar readily from the syrup in which it is now ready to be immersed. The next process to which the rind is subjected is that of a slow absorption of sugar, and this occupies no less than eight days. The absorption of sugar by fresh fruit in order to be thorough must be slow, and not only slow but also gradual; that is to say, the fruit should be at first treated with a weak solution of sugar, which may then be gradually strengthened, for the power of absorption is one that grows by feeding. The fruit has now passed into the saturating-room, where on every side are to be seen long rows of immense earthenware vessels, about four feet high and two and a-half feet in extreme diameter, in outline roughly resembling the famed Etruscan jar, but with a girth altogether out of proportion to their height, and with very short necks and large open mouths. All the vessels are filled to the brim with citron and orange peel in every stage of absorption—that is to say, steeped in sugar syrup of about eight different degrees of strength. This process almost always occupies eight days, the syrup in each jar being changed every day, and with vessels of such great size and weight, holding at least half a ton of fruit and syrup, it is clearly easier to deal with the syrup than with the fruit. To take the fruit out of one solution and to place it into the next stronger, and so on throughout the series, would be a very tedious process, and one, moreover, injurious to the fruit. In each of these jars, therefore, there is fixed a wooden well, into which a simple hand suction pump being introduced, the syrup is pumped from each jar daily into the adjoining one. A slight fermentation next takes place in most of the jars, but this, so far from being harmful, is regarded as necessary, but is not allowed to go too far. There is yet another stage, and that perhaps the most important, through which the peel has to pass before it can be pronounced sufficiently saturated with sugar. It is now boiled in a still stronger syrup of a density of forty degrees by the testing tube, and this is done in large copper vessels over a slow coke fire, care being taken to prevent the peel adhering to the side of the vessel by gently stirring with a long paddle-shaped ladle. This second boiling occupies about an hour. Taken off the fire, the vessels are carried to a large wooden trough, over which is a coarse open wire netting. The contents are poured over this and the peel distributed over the surface of the netting, so that the syrup—now thickened to the consistency of treacle—may drain off the surface of the peel into the trough below. The peel has now taken up as much sugar as is necessary. Next comes the final process, the true candying, or covering the surface of the peel with the layer of sugar crystals which is seen on all candied fruits. To effect this a quantity of crystallised sugar—at Leghorn the same quality of sugar is used as is employed in the preparation of the syrup—is dissolved in a little water, and in this the now dried peel, taken off the wire netting, is immersed. The same copper vessels are used, and the mixture is again boiled over a slow fire. A short boiling will suffice for this the last process, for the little water will quickly be driven off, and the sugar upon cooling will form its natural crystals over the surface of the fruit. Poured off from these vessels it is again dried upon the surface of the wire netting as before described. The candying is now complete, and the candied peel is ready for the packing-room, to which it is carried in shallow baskets. In the packing-room may be seen hundreds of boxes, of oval shape and of different sizes, for each country prefers its boxes to be of a particular weight, Hamburg taking the largest, of 15 and 30 kilogrammes, the United States of America preferring smaller, of 10 and 12 kilos., whilst England takes the smallest, of 5 kilos., and one containing about 7 English pounds.

COAL DEPOSITS IN VENEZUELA.

The United States Consul at Maracaibo says that in the district situated between the Sierra de Tulé and the river of the same name, considerable importance is given to the territory by the abundance of carboniferous deposits. At little more than a distance of one kilometre from the River Tulé, near Los Ranchos de Guasdual, was found the first view of coal among the many discovered during an exploration which has been undertaken by the Government. From this point, for a distance of five kilometres, exist fourteen veins more of the same mineral, visible in the banks of the river, many of them measuring from 10 to 30 feet in diameter. A number of these veins traverse the bed of the river at a depth of more than three metres, and it is stated that they probably extend a long way on the other side. Continuing the exploration along the river for a distance of ten kilometres, it is asserted that its banks as far as the foot of the Sierra are an almost homogeneous composition of the same mineral, visibly cropping out with scarcely any interruption. These croppings are also visible at various points of the banks of the creeks which empty into the Tulé and Riocito, and abound in the last-named river for a distance of more than twelve kilometres. Consul Plumacher says that in view of these facts, it may be safely affirmed that in that part of the territory of the State included between the Sierra de Tulé, the river of the same name, the Sierra de Guasdual, and a line drawn from the extremity of the latter to the Sierra de Tulé, there exists a carboniferous formation which occupies an approximate area of three hundred square kilometres. Three of these coal

veins are in constant combustion, the causes for which and the date of commencement are unknown. The first of these three is situated on the right bank of Algibe Creek, about one kilometre from Los Ranchos de Guasdual. It does not eject either smoke or flame, and its state of combustion is revealed only by the elevated temperature of the spot. The second ignited vein is upon the left bank of the River Tulé, six kilometres distant from the Ranchos de Guasdual. At a distance of fifteen or eighteen feet above the level of the river there is a small fissure, measuring about eighteen inches by six, from which smoke is constantly issuing. To the right and left of the crevice are several smaller ones which do not eject smoke, but which give out an intense heat, showing the activity of the combustion. The third vein is found close to the Sierra, on the bank of a creek, and at a short distance from the River Tulé. From it smoke is constantly issuing, accompanied frequently by flames whose brilliancy, it is said, may be distinguished on clear nights from localities only a few miles west of Maracaibo. All this coal is of one quality, and of the bitumenous variety. It is very similar to cannel coal, although of less density and containing less bitumen, and appears free from sulphur and other substances which many other coals contain. It burns freely in the open air, almost without smoke or sparks, producing a bright and clear flame, with an intense heat. It does not "clink" or disintegrate to any great extent in the process of combustion, and leaves a very small residue of ashes. It is believed that this coal is far superior to any other as yet discovered in Venezuela, and Consul Plumacher states that it is to be regretted that the State has not sufficient resources to undertake the working and development of this wealth, lying less than 100 kilometres from Maracaibo. No mine in Venezuela, it is said, offers advantages equal to those of Tulé, not only on account of the excellent quality and extraordinary abundance of the coal, but also from the facility of working. All the veins are found at such a slight depth below the surface that nothing more than trenches are needed for their development. In only one locality, and for but a short distance, would galleries be necessary, and these could be easily run both straight and transversely, and in no part of the carboniferous territory would it be necessary to erect machinery to raise the coal to the surface.

CULTIVATION OF SUGAR IN PERSIA.

The sugar-cane was introduced into Persia from its original home in Bengal at a very remote period. The first indisputable mention, says the United States Consul at Teheran, of sugar by a western writer is that by Moses Chorencrisis, in the 5th century, who describes the sugar-cane as he saw it growing on the banks of the Karún river, which joins the Shott-et-Arab at the head of the Persian Gulf. In the olden times, and as late as the 14th century, the sugar-cane was much cultivated in Susiana, the country intersected by the Karún river, and principally near Ahwaz and Jundi Shapur. Susiana was then one of the principal intermediate commercial stations between the present towns of Dizful and Shushter, and had its water from the Karún river by means of canals cut from the right bank some distance above Shushter, and from the Diz river by canals cut from the left bank, near the town of Dizful. With the decline of Jundi Shapur, in the 13th century, the canals were neglected, and the cultivation of sugar-cane necessarily ceased. The present Ahwaz is a small village of about fifty houses on a mound, which covers the ruins of a part of the former town. Hundreds of millstones or wheels, formerly used for squeezing the juice out of the cane, are lying about in all directions. Persian historians do not ascribe the ruin of Ahwaz to the failure of the water supply, but to scorpions. They say that an Indian merchant, with the view of raising the price, bought up all the sugar he could, and stored it for a year or two; when he opened his stores all the sugar had turned into scorpions; millions of scorpions came out of the sugar store, all the inhabitants of Ahwaz fled, and the city has remained a desert from that day. There is still current in Persia a proverb which says, "At Ahwaz sugar-cane produces scorpions," and one of the Persian poets, referring to the ringlets of his mistress, says, "they are as deadly as the scorpions of Ahwaz." The only district in Persia where sugar-cane is now cultivated is Mazanderan, which is the principal rice-producing district, and it was probably introduced during the last century. The sugar cane in Mazanderan requires twelve months to ripen, but the canes are small and poor, few being ever found thicker than a man's finger, and the produce is of very inferior quality, being dark and moist. Both of these defects in all probability arose from want of skill in the cultivation and preparation of this valuable plant. The sugar is mostly consumed in the province; a considerable portion, however, is exported to Gilan, and some to Russia. The canes are planted in slips with two or three joints, in February or March, and ripen about eight or nine months after, having then a height of about five feet. One mill turns out per day about 200,000 pounds of jûice, and about 60 to 70 pounds of sugar. The juice, therefore, yields 30 to 35 per cent. of sugar. Only raw sugar is manufactured in Mazandaran. There are no sugar refineries. The raw sugar is sold at the place of manufacture in the villages at from three-farthings to a penny a pound, and in the markets of Sari and Barfunish at from a penny to twopence a pound, according to quality. In some towns of Persia, principally Yezd and Ispahan, Jaru raw sugar was, up to a few years ago, refined and made into loaf sugar. The loaf sugar made in Persia was seldom

perfectly crystallised, and was on that account very soft; it was also more or less impure and dirty, the loaves not having been properly washed, and the green syrup not having been completely removed. The imported loaf sugar becoming very cheap, sugar refining in Persia ceased to be profitable. The general Persian word for sugar is *shakar*, the sugar-cane is *udi-i-shakar*, while refined sugar is *kand*, a loaf of sugar is *kelleh-i-kand*, sugar-candy is *nabat*. Persia is famous for its sugar-candy. This is made in the ordinary way, but is left to crystallise on strings in a bowl of earthenware or china. The strings are kept at the bottom of the bowl by a piece of lead, and at the top by strips of wood; when taken out of the bowl it retains its shape, and is called *kasch-i-nabat*, *i.e.*, a bowl of candy. Consul Schindler is of opinion that sugar-cane would thrive well in some districts of Persia and Southern Persia, at altitudes of from 1,000 to 3,000 feet above the level of the sea. The plain of Bugh-i-Mailik, east of Shushter, at an elevation of 2,600 feet; that of Shapur, west of Shiraz, elevation 2,500 feet; those of Fihift and Rudbar, south of Kerman, elevation 2,500 feet, appear to him to be eminently suited to the cultivation of the sugar-cane.

Correspondence.

STATE AND FREIGHT.

Since the Conference in May, 1888, the Sheffield canal project has taken shape, and one hears of a well-supported proposal to have vessels of 300 or 400 tons unloading at Worcester. Though such schemes have dividends for their object, it is something that the advantage of enlarged waterways is beginning to be realised even in Great Britain.

France, besides making many new canals, has brought more than 1,200 miles of waterway, to what is now the international standard, while the Conventions of 1883 and the *troisième réseau* are the results of carefully making terms with the great railway companies, before prospectively enriching them by State-aided branches.

The lowness of railway rates in Belgium is well known. The Irish Commission of 1868, after comparing that rich kingdom with their own poor island, reported that an assimilation of rates would cause an immediate annual loss of £645,701. Nevertheless, the Canal du Centre, near Charleroi, has lately been completed at considerable cost. The difference between Belgian and Irish fuel is that the latter is bulkier in proportion to its value.

In Holland, the land at any rate of *canaux* and *canards*, cattle often come to market by steamer; but statistics of water transport are hard to get, because the channels belong to the State, the provinces, or the burghs. The Ministry of "Waterstaat, Handel en Nijverheid," however, watches closely over such things, and the chief railways have been leased to companies on terms which, in 1883, were yielding the State only ·427 per cent. on the capital expended on them. It does not follow, however, that such scattering of national wealth may not have increased it.

The Italian Commission which considered the relations between the State and the transporting companies comprised fifteen of the best brains in the kingdom. Its report and evidence, published in 1881, filled seven volumes, but by no means closed the affair.

Nearer home one sees how wide the question of State intervention must necessarily be. Already the West Highlands are claiming aid for several projects, and it becomes clear that unless definite and durable principles be fixed, such matters will keep swaying with party tactics.

In a recent article, M. de Beaulieu mentioned Ireland as an instance of a country naturally poor, but better provided with railways than France herself, because the island had been able to attract private enterprise. On the other hand, the deepest of Ireland's rivers, which links her chief lake with the sea, has been under two Boards, responsible for drainage and navigation respectively. The not unnatural result has been a channel silted in some cases to the extent of 20 per cent. of its original profile, and consequently carrying little traffic. It is now proposed to render the recent Coleraine estuary improvements comparatively fruitless by abandoning the inland navigation.

On Irish public works an outlay of about a million sterling is now contemplated. This, while freeing the railways from water competition, will swell their dividends by creating feeders. We are told nothing of the course to be adopted with the Trunk lines. A Society devoted to Arts, Manufactures, and Commerce may, however, naturally interest itself as to the relations which should subsist between State and freight in all parts of the Union.

WALTER M. T. CAMPBELL.

Edinburgh, N.B., June 5th, 1889.

General Notes.

CONGRESS OF PROVIDENT SOCIETIES.—The third quinquennial session of the Congrès Universel des Institutions de Prévoyance will be held at the Palais du Trocadero, Paris, from the 2nd to the 7th of September. Subjects connected with Savings Banks, Friendly Societies, Annuities, and Co-operative Unions will be dealt with at the Congress. All communications relative to the Congress should be addressed to the General Secretary, 68, Rue Babylone, Paris.

Journal of the Society of Arts.

No. 1,912. Vol. XXXVII.

FRIDAY, JULY 12, 1889.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

Proceedings of the Society.

CANTOR LECTURES.

HEAT ENGINES OTHER THAN STEAM.

By H. Graham Harris, M.Inst.C.E.

Lecture I.—Delivered May 6th, 1889.

Syllabus.

Introductory—Definition of a Heat Engine—What is Heat?—Count Rumford's Experiments—Davy's Experiments—Heat a Mode of Motion—The Big Gun a simple Heat Engine—Conversion of Heat into Work, and of Work into Heat—Specific Heat—Latent Heat—Carnot's Doctrine—His ideal Heat Engine, reversible; and impossible—Absolute Zero—Steam Engine as basis of comparison—Heat Units—Joule's Equivalent—Available Heat—Real Efficiency of Steam Engine — Other Heat Engines have no Boiler—Effects of Expansion.

Sir Frederick Bramwell, in his Presidential Address to the members of the British Association, at their meeting at Bath, in September last, made use of the following pregnant words:—

"At the York meeting of our Association, I ventured to predict that unless some substantive improvement were made in the steam engine (of which improvement we have, as yet, no notion), I believed its days for small powers were numbered, and that those who attended the centenary of the British Association, in 1931, would see the present steam engines in museums, treated as things to be respected, and of antiquarian interest to the engineers of those days, such as are the open-topped cylinders of Newcomen and of Smeaton to ourselves. I must say I see no reason, after the seven years which have elapsed since the York meeting, to regret having made that prophecy, or to desire to withdraw it."

As I have said, these are pregnant words, and when I was requested to deliver this course of Cantor Lectures it seemed to me my time would be well spent, and the opportunity which the Council of the Society of Arts gave me would be well utilised, if I made them the text for that which I had to say, and if I endeavoured to bring before those who honoured me with their presence some idea of the theoretical values of the various forms of heat engine already devised and in use, considering these in relation to their practical possibilities, and also describing for each class, as far as time would permit, the mechanical means by which the progress already made has been obtained, pointing out also certain of the difficulties which have to be overcome.

These words of Sir Frederick were deliberately repeated by him after an interval of seven years, and on so public an occasion (if I may so put it), as his Presidential Address to the members of the British Association. As I have said, it shall be my task to try to bring before you the various reasons which, after careful consideration, seem to me to render this prophecy certain of fulfilment.

Another justification (if one were needed) for my choice of this subject is, that it is, to some extent at least, popular. This is evidenced by the fact that, in the year 1887, there were some 220 patents taken out in connection with it, and that the numbers per annum are steadily increasing; this proving that there are many minds continually at work grappling with and considering the difficulties, with the natural result that there is steady, although it may be slow, improvement.

Let me first try to illustrate to you "graphically" the measure of success that has already been achieved in "Heat engines other than steam," comparing this with that which has been obtained in the steam engine itself.

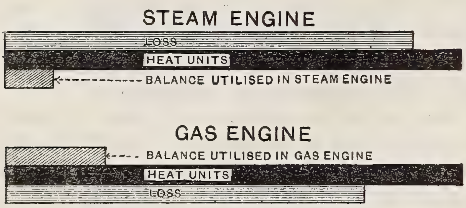
I will ask you to look at these cubes, and to assume the larger one—that coloured black—represents the amount of heat in a definite quantity of fuel. Then the smaller one which I am now holding up—which is coloured red—will represent the useful result obtained by aid of that amount of heat in a fairly good steam engine of the present day. You will see how comparatively small it is; as a fact, its contents are only about 11 per cent. of those of the black cube, while this other red cube which I am now holding up represents the useful result obtained by the employment of the same

quantity of heat as that shown by the black cube in an ordinary gas engine. See how much larger it is than the other red cube. As a fact, it is nearly twice as large; *i.e.*, its contents are nearly 22 per cent. of those of the black cube, which we assumed to represent the amount of heat at our disposal.

I have taken the gas engine as the heat engine to compare with the steam engine, because the gas engine is the form of heat engine other than steam which is the most common, and of which we, at present, have the most experience.

Fig. 1 gives you the same comparison, but in another way. You will see there that the black shaded portion of both figures represents a similar amount of heat -- the portions which are shaded horizontally represent the loss, and the portions shaded diagonally the small balance which in each case is utilised.

Fig. 1.



One of the greatest difficulties with which I have had to contend in the preparation of these lectures has been to determine, for each particular branch of the theoretical portion of my subject, how far I ought to make that which I have to say absolutely elementary, and therefore, somewhat popular, or how much I should take for granted was already fully known to my audience.

To an extent I am governed in this decision by the short time at our disposal, but on consideration, it seems to me better I should err on the side of repeating to you many things which you already know. I am the more ready to do this, because I think it is well that I should at least put into words my ideas of even the elementary portion of our subject.

It will, perhaps, be as well for me to state exactly what I mean by a "heat engine." This title does not necessarily imply moving machinery, but such an engine may be defined as any apparatus or machine to which heat is applied, or in which heat is generated, and from which work in any form results; or, to put it shortly, a heat engine is any apparatus in which heat is transposed into mechanical work. For instance, a smelting furnace is a heat engine, a steam boiler and a gun are both of them heat engines; and although you may laugh, and think I am stating a paradox, yet a "cold-producing" apparatus is frequently a heat engine.

The philosophy of heat has been considered, and has from the earliest days been experimentally investigated by some of the ablest men who have ever lived. As a consequence, the literature in connection with it is large.

For the complete consideration of the more abstruse questions involved, I must refer those of you who are interested to the works of these men. I may, however, mention two or three of the more recent of those books which treat more particularly of the theory of the heat engine, and will well repay careful consideration and study.

In the year 1884, the late Professor Fleeming Jenkin, in the lecture which he delivered before the Institution of Civil Engineers, on "Gas and Caloric Engines," dealt fully with the theory involved in the working of many forms of heat engines. Professor Goodeve has recently published a work also dealing fully with the theory. Mr. Dugald Clerk (see his work published in 1886) has experimentally investigated the question of the gas engine.

Mr. W. Anderson (Member of Council of the Society of Arts and of the Institution of Civil Engineers, delivered in this room a series of six lectures, in the Session 1884-85, under the Howard Trust, in which the theory, with some of its applications in practice, was also fully considered, and in Mr. Anderson's masterly manner. Further, there has been this Session published in the *Journal* of the Society, and read and discussed before one of the Wednesday evening meetings, the report of the judges on the trials of motors for electric lighting purposes, and the paper by Professor Kennedy on these trials. This paper and the report necessarily dealt largely with the subject of gas engines, some of the best of which were tried.

I hope, however, that there is yet room for me; room for comparison of the theory and of the theoretical values with the practical possibilities, and for comparison of these with the results that have, in practice, been attained up to the present. There is room also for suggestions as to the direction in which further improvement must be sought, not only in those engines which are alone dealt with in the above books and papers, but in others new

since their publication, or which have, in new forms, been recently proposed.

It is necessary, in order to consider with understanding the possibilities of heat engines, that we should investigate, to some extent at least, the science of heat and its laws. I do not, however, propose to do this to any greater degree than will enable us to comprehend the practical points in connection with our subject; nor do I propose to recapitulate the various ideas which have from time to time been propounded as to what heat really is; but I will ask you to accept that which is now universally agreed to be proved, namely, that heat and motion are convertible the one into the other, or in other words, that the title of that interesting book by Professor Tyndall is correct to its uttermost meaning, and that heat is—"A Mode of Motion."

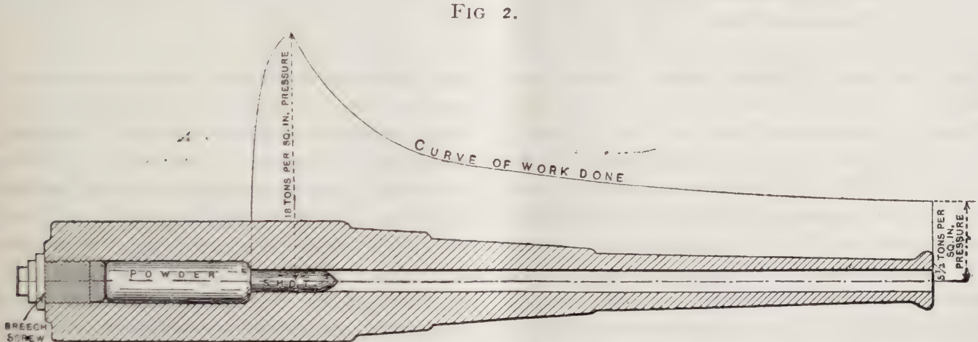
Two of the earliest of those who investigated and propounded the true philosophy of heat were Count Rumford and Sir Humphrey Davy. The latter proved experimentally that, by rubbing one piece of ice upon another in *vacuo*, the temperature of the ice being 28 degrees, or four degrees below the freezing point on the Fahrenheit thermometer, heat was produced; the ice was melted, and the resultant water had a temperature some three or four degrees in excess of freezing point. He showed that the heat necessary for this increase of temperature could only have arisen from the friction of the one piece of ice upon the other. This experiment was even more conclusive than it at first sight appears, as we shall see when we come to deal with the questions of specific heat and of latent heat.

Count Rumford also had, in a paper read before the Royal Society, on January the 25th, 1798, shown that in the boring of a brass cannon heat was produced, which heat was sufficient to boil water in which the boring tool and the portion of the cannon being operated upon were contained.* He had also, as early as 1778, stated that he had proved experimentally that a gun which was fired without a bullet was hotter after the firing than when fired with a bullet. Count Rumford was not, at that time, cognisant of the dynamical theory of heat, but his suggestion, as I understand it, was that a portion of the heat developed by the explosion of the powder was dissipated or absorbed, in some way or another, in pushing the bullet out of of the gun. We now know that this heat which disappears is transformed into the motion of the bullet.

Let us consider this discovery announced by Count Rumford in relation to a big gun (which is one of the simplest forms of heat engine, completing its work, as it does, in one stroke), and let us see whether, when we have realised the reasons for that which Count Rumford observed, it will not carry us one step at least towards a complete understanding of our subject.

In Fig. 2 you have a sectional diagram of a big gun. At the left-hand end you see the

Fig 2.



Big Gun.—The Simple Heat Engine.

breech closed by the breech screw, and here the space occupied by the cartridge is shaded and marked with the word "powder." In front of this you have the shot. Now, when the gun is fired the solid powder is converted, as combustion takes place, into gas, and heat, and, therefore, heat and pressure are generated, and motion is rapidly imparted to the shot until it is expelled from the gun at a speed which, in these days, reaches approximately

* See Tyndall's "Heat a Mode of Motion," 1887 edition, p. 47.

a mile in two and a half seconds of time, or, if continued, of nearly 1,500 miles an hour. Further, you will see that as the shot is moved forward in the gun, the space behind it, *i.e.*, the space between it and the forward end of the breech screw, necessarily goes on increasing, and is at its maximum just as the shot leaves the muzzle. You will realise also that the gases which result from the burning of the powder would, if the burning were instantaneous, be at their maximum pressure at the moment of explosion, and that, as the space in which they are contained is increased by the forward movement of the shot, the gases having to occupy this larger space will become less in density, and, therefore, lower in pressure.

If you will look above the section of the gun, you will see a curved full line which, at the breech end, is at its greatest distance from the dotted centre line through the gun, and is nearest to that centre line at the muzzle end. Now the vertical distance between this centre line and the curved line is intended to represent, at every portion of the travel of the shot, the pressure per square inch which the gases are exerting. At the breech end this vertical distance represents a pressure of about 18 tons on the square inch, and, at the muzzle end, the vertical distance represents about $5\frac{1}{2}$ tons on the square inch, which will, in this case, exist at the moment when the shot is leaving the gun. The space enclosed between the full curved line and the dotted centre line through the gun, represents the "work" done by the combustion of the powder charge, a portion of which work must have been put into the shot, in order to cause it to attain the velocity with which it leaves the muzzle.

Now, if that which I have told you is correct, and if heat and motion are convertible the one into the other, and if a portion of the heat due to the explosion of the powder charge, and represented by this space, has really been put into the shot in the form of motion, we should be able to reproduce from the moving shot the heat which in it has been transformed into motion. You, all of you, know we can do this. You, all of you, know that if we suddenly arrest the motion of the shot, heat is developed, and that, in fact, if the shot had sufficient velocity, and was composed of a metal having a low melting point, it might be fused.

A peculiar illustration of this transformation of work into heat by the stoppage of a rapidly moving projectile, is afforded by an incident which Sir Frederick Bramwell has related to me. He was present at the firing of one of the earlier Palliser projectiles. These are, as you know, made of cast-iron, the points being chilled in the casting, so as to harden them, with the result that, although cast-iron is very brittle, yet the shots will penetrate a thick armour plate, such as would stop a softer projectile.

When this Palliser shot was fired, it passed completely through the armour plate, the point of it, however, being broken up in doing so. Sir Frederick went to pick up one of the broken pieces. Someone present cautioned him that it would be hot; he, however, knowing it could not be hot on the inside—the motion (or heat) in it having been transformed into the work of penetrating the plate—took hold of it on the inside, and found that, as a fact, it was not hot; and it was not, because the "work" which had been put into it by the combustion of the powder charge in the gun had not been re-transformed into heat, but had been absorbed or dissipated by the shot passing through the armour plate. If the shot had been of a soft metal, say mild steel, it would have been "set up" or "burred over" when the plate was struck, and its motion would then have been transformed into heat, and Sir Frederick could not have touched the broken piece of shell without being burnt. Of course, on the outside of the shot, where it had been in contact with the plate, it was hot, due to the friction of that contact.

Let us now revert to the big gun diagram, and see what it has taught us. We have learnt that heat and pressure are developed by explosion or combustion of the powder charge; that as the shot moves forward the gases expand, or their density is lessened, and that therefore the pressure lowers; that a portion of the heat is transformed into motion, and is stored up in the shot, and that we can cause that heat to reappear by arresting the motion of the shot; and this being so, it follows that when the gun is fired without a shot, as none of the total quantity of heat is abstracted for the purpose of giving velocity to the shot, it should be hotter than when fired with a shot in it, proving, therefore, the truth of Count Rumford's assertion.

Further, we can see that expansion or dilatation of the gases produced by explosion takes place as motion is created, or as work is done; we shall find that a similar expansion of the working agent almost invariably accom-

panies any transposition of heat into work. I shall have to refer to this very frequently later on.

We can also realise, from our big gun diagram, that, while the addition of heat produces expansion, the converse is true, and the abstraction of heat will lessen the density of a gas; or what is the same thing stated in another way, will lessen its pressure if the volume remains constant.

It is true of almost every body, and in all the various "perfect and complete states" of each body—*i.e.*, the solid, the fluid, or the gaseous—that the addition of heat causes expansion; but it is also true that with almost every body, at the critical periods of change of state from the solid to the fluid, or from the fluid to the gaseous, there is an absorption or disappearance of the heat which may be put into it, which heat can only be caused to reappear when the body is allowed or compelled to reassume the more solid state, or its lower state of being, if such an expression may be permitted. To this I will refer again almost directly after dealing with the question of specific heat.

Solids expand by the addition of heat, though in less proportion than gases. An instance, familiar to those of us who are engineers, is afforded when we have to deal with a cast-iron steam pipe of great length, subjected as they are to considerable variations of temperature. We know that in a pipe of 800 feet we have to allow for a variation of, roughly, one foot for each difference of 200 degrees of temperature to which the pipe will be exposed; that is to say, a pipe which is 800 feet long at a temperature of 32 degrees, or at freezing point, will expand to nearly 801 feet if it is filled with boiling water.

Mr. Benjamin Baker tells me that at the Forth Bridge he has made an allowance of three-fourths of an inch for every 100 feet of length, and this to provide for the difference of summer and winter temperatures, which may be as much as 100 degrees.

A still more familiar instance of the effects of variations of temperatures is afforded by the ordinary mercurial thermometer. Heat causes the liquid mercury to expand or dilate, cold causes it to contract. The expansions of the steam-pipe and of the mercury, however, are small in comparison with the expansion of gases; "steam," "air," or whatever they may be, for an equal increase of temperature.

We know if we have a bladder partly filled with air and we heat it, it expands, filling that bladder—or appearing to fill the bladder entirely; we heat it still more, the expansion is greater; and we can heat it till the pressure increases so much that it exceeds that which the bladder is capable of bearing, and the bladder bursts. This is a simple illustration of the fact of increase of temperature causing expansion, and also causing increase of pressure.

Let us now consider the question of specific heat, and let me here caution you as to the difference between the words "heat" and "temperature." This caution is necessary, for, as I am about to show you, heat may be added to, or taken from, a body without corresponding change of temperature.

Experiment has proved that different solids and fluids require varying quantities of heat to be put into them, or to be taken from them, in order to increase or to lower their temperature through any given range.

The amount of heat absorbed or given off, as the case may be, by any substance to vary its temperature through any given number of degrees, is termed "specific heat."

A "quantity" or an "amount" of heat is always spoken of as so many "heat units" or "thermal units." By an English "heat unit" is meant that amount of heat necessary to raise 1 lb. of water from 39·1° to 40·1° Fahr. *i.e.*, the amount of heat necessary to raise 1 lb. of water at the temperature of its greatest density, 1° Fahr.

Of all bodies, water is the one which opposes the greatest resistance to a change of temperature, that is to say, it requires a greater amount of heat imparted to it, or abstracted from it, to cause a given change of temperature in it, than does any other solid or liquid we know. Water, therefore, is used as the standard of comparison, and its specific heat is taken as unity. From this it follows that the specific heat of all other bodies, whether solid, fluid, or gaseous, must be expressed in fractions, or in parts of unity.

The specific heat of water itself is not absolutely constant at all temperatures, it becoming slightly increased at 212° Fahr., or at its boiling point; but it is sufficiently constant, at all events, for us to ignore the variation.

You will now comprehend the definition of specific heat. It is the ratio of the quantity of heat necessary to raise or to lower a given weight of any given body through a given variation of temperature—say one degree—to the quantity of heat required to raise or lower the temperature of an equal weight

of water through the same variation of temperature.

We have talked of the expansion of cast iron and of mercury, and have noted how small are such expansions for equal changes of temperature compared with that of a gas. Let us consider what their relative specific heats are, and see what quantity of heat will have to be added to 1 lb. of each to raise its temperature by the 200° with which we have dealt before.

Regnault's experiments have told us that the specific heat of cast iron is ·12983, therefore ·12983 × 200° × 1 lb. = 25·966 heat units. The same experimenter gives the specific heat of mercury as ·03332, therefore ·03332 × 200° × 1 lb. = 6·664 heat units, or in other words, about 1-8th the heat needed to raise 1 lb. of water 200° would raise 1 lb. of cast iron 200°, while 1-30th the heat required for the water would raise the same weight of mercury through the same temperature; and, as between the two metals, nearly four times as much heat would be required to raise a given weight of cast iron through a given range of temperature as would be required to raise the same weight of mercury through the same range.

One of the best common-place illustrations of specific heat is, I think, afforded to us if we look upon it as equivalent to "appetite."

Two persons are equally hungry, that is to say, that if there were any accurate instrument by which we could test them, we should find that they were in an equal state of wanting their dinner. They sit down to eat it, and when they have finished, if we could again apply the "hunger-meter," we should find that they were equally satisfied. When, however, we come to examine as to the quantity of food consumed by each, we find that one has made away with some 5 lbs., while the other has only needed ½ lb. to satisfy him to an equal degree. So with bodies and heat. Here experiment has shown one body requires five portions of heat to raise it through a certain range of temperature, while another body only requires one portion of heat to raise it through an equal range.

One of the distinguishing characteristics of all gases is, as we shall now find, that their specific heat does not vary, under similar conditions, to any appreciable extent.

Let us try to understand this question of the specific heat of gases (one of the most difficult points which it is necessary for us to fully comprehend in connection with the theory of our subject), and let us refer again to the diagram of the big gun. You will remember that when the gun did the work of driving out the shot, a portion of the heat of explosion was transformed into the motion of the shot, and we were able to reproduce the heat by suddenly arresting that motion. In this case, therefore, we proved that we had a lessening of the total quantity of heat developed by the combustion of the powder charge, due to its transformation into mechanical work. As we shall see, it is necessary to bear the possibility of such a transformation in mind when dealing with the question of the specific heat of gases.

If we had maintained the volume of the gases in the gun constant, that is to say, if we had not allowed the shot to move at all—thus preserving the space in which they were contained at all times constant—then the amount of heat necessary to be imparted to the gas, or to be abstracted from it, in order to cause a given change of temperature, would be practically the same for all temperatures; that is to say, a gas when the volume is maintained constant follows the same law, or principle, in respect to specific heat, as governs the case of a solid or of a fluid; but, allowing the gases to expand or increase their volume as we did, that is to say, allowing the space in which they were contained to increase by the forward motion of the shot, we should find, if we tried the experiment, that the amount of heat necessary to be imparted, in order to maintain the same temperature, would be as much greater as would be represented by the difference in volume of, or space occupied by, the gases.

Let us put this difference of the specific heat of gases, under different conditions, into figures:—The specific heat of a gas—say air—when the volume is kept constant, but the pressure is allowed to vary as the heat is imparted or abstracted, is ·169, or practically 1-6th of that of water, but the specific heat of the same gas (air), when the volume is allowed to vary as the heat is imparted or abstracted, but the pressure is kept constant, is ·238, or a little less than 1-4th of that of water. You will see that the ratio between the two is as 1 to 1·408.

This is the way in which this question of the difference of the specific heat of gases, under varying conditions, is usually stated in the text-books; but it has been pointed out by Sir Frederick Bramwell and others that the bare statement thus made is hardly in-

telligible and is incomplete. They show that the increase of the specific heat of a gas, when its volume is allowed to vary, arises from the amount of heat necessary to be turned into work, in order that the gas, in increasing its volume, shall be capable of displacing that portion of the atmosphere which it does displace; that is to say, if while maintaining the temperature constant we had allowed the shot to move forward in our gun, and assuming that no work was required for moving that shot, and that no heat was lost in any way whatever, then the extra amount of specific heat which the gas would require as its volume increased would be exactly that necessary to overcome the pressure of the atmosphere, and to do the work of displacing that portion of it which would be occupied by the increased volume of the gas.

I wish time would allow me to go into this matter more fully, but we shall have again to refer to it when dealing with the expansions arising in the cylinders of heat engines, when I will endeavour to put the explanation in other ways, so as to enable you to completely grasp this rather complicated question.

We have one more question of heat to consider, which almost logically follows from that which we just discussed, and that is "latent heat."

Let me refer again to our appetite illustration, in order to enable you to realise this question of "latent heat." Imagine that the two persons who have already assisted us have been for a long period without any food, and imagine that although they eat a hearty meal, yet, when they get up they do not feel their hunger satisfied, and that our hunger-meter registers no more satisfaction after the meal is over than it did when our friends sat down; that is to say, all the food which they had consumed would, as far as the hunger-meter was concerned, be "latent," and this instrument would fail to indicate to us that they had eaten any food at all. A similar thing happens when we put heat into a body which is, say, a fluid, but is at the critical state of change in its condition from fluid to gaseous; the heat which then disappears is termed the "latent heat of vaporisation." The thermometer will not register the heat which is at that time put in, that heat being necessary to make the change of state of the body. A similar apparent disappearance of heat takes place when the change is from solid to fluid; this is termed the "latent heat of liquefaction."

Let us take water again for our illustration. A certain definite addition of heat is necessary to raise any given weight of water each degree of temperature up to the boiling point; but then, in order to change the water—which is at boiling point—to steam, which is not, however, at any higher temperature, a large quantity of heat has to be added, which seems to totally disappear, and can only be caused to re-appear by re-changing the gas—steam—into the fluid—water.

As a fact, we may look upon steam as a mixture of heat and water, the heat really being absorbed by the particles of water at the time of its change into steam, and not making itself sensible in the instrument with which we measure the heat; and we may also look upon water as a mixture of heat and ice.

You know we can tell by the sense of touch the difference of temperature of a body. Now, if it were possible for us, without burning ourselves, to put our hands into boiling water and realise its temperature, we should suffer no more from the heat than we should by putting our hands into steam at atmospheric pressure; and yet we find by experiment that, in order to change the fluid (water) into the gas (steam), we must add a quantity of heat which would be sufficient to raise the temperature of the water, if it remained as water, 966·6°.

James Watt was one of the earliest to discover and publish this fact of latent heat in reference to water and steam, and in 1781 he estimated the number of heat units necessary to make the change in 1 lb. of water as 950, but he subsequently put the numerical value at 960. Corrections were made by Regnault, based on experiments which he had made, and his formula gives the true value, namely, that which I have stated—966·6 units—as the quantity of heat which disappears or becomes latent when each 1 lb. of water, at the temperature of boiling point, is transformed into steam, which will only be at the same temperature. Further, I must remind you that in order to change 1 lb. of ice at 32° into water which is only at the same temperature, 142·4 units become latent or disappear. You will now fully realise the necessity for my caution to you not to confuse the terms "heat" and "temperature."

(To be continued.)

Miscellaneous.

JAPANESE ART PRODUCTIONS.

A lecture on the "Art Productions of Japan" was delivered by Mr. Lasenby Liberty, on Saturday afternoon, June 1, in the buildings of the Bijitsu Kiokai, at Sakuragaoka, Uyeno, Tokyo, and the following report of this lecture is taken from the *Japan Daily Mail* :—

A period of disruption of the traditional ideas has passed, and is still passing, over Japan through the removal of the artificial barriers which separated the Japanese from the rest of the civilised world, and no one who is in the least familiar with Japanese work, or has been a few weeks in Japan, can fail to admire the quick receptive faculty, adaptability, and inventiveness of the Japanese mind as shown under these altered circumstances. The theme of my address, the note that I would dwell upon, is one of warning, lest this most valuable and admirable quality in the Japanese character should of itself (if allowed to develop without restraint, and a due exercise of discrimination and balanced judgment) be the gravest danger and the most formidable impediment in the pathway of the future growth and continuity of the poetic, bold, and original art of Japan.

I come as a visitor to Japan, and yet as one who has been for more than twenty-five years intimately associated with things Japanese. During those five and twenty years I have had the advantage of seeing all that was most beautiful among the art manufactures of Japan that have been sent to my own country, and, I think I may say, broadly speaking, to Europe. I have during that time, as far as my sphere and influence permitted, sought to foster and popularise Japanese art in England by setting before the English people, and distributing through commercial channels the typical products of the Japanese workman, and excluding, as far as possible, all such as were mere imitative productions of European art.

In earlier days mueh discouragement was given to enterprise in Japanese imports by those who could see in Japanese manufactures only novelty and eccentricity, and who predicted for them that speedy neglect which inevitably attends all enterprises and all manufactures that have nothing in them save an attempt to gratify the ever insatiable craving of humanity for "something new."

There, of course, was, and I am thankful to say is, an immensity besides this in Japanese art work, though novelty and eccentricity may also be present. There is a soul, a spirit, an intent, a thoughtful intelligence underlying and directing it—the intent to form, from whatever medium may be employed, an object that, first, shall (if intended for a practical or useful purpose) fulfil in the most simple and direct manner the purpose of its creation; secondly, that shall be pleasing or graceful in form; and thirdly, that, when ornamented, the ornamentation shall grow out of, or be within, the lines of the form and in unison with the object of its creation. In other words, there is in Japanese art the fulfilment, from a different standpoint and in an original method, of the acknowledged European classical and modern canons of art. So much is this so, that in every part of the civilised world where Japanese art was at all properly (that is representatively) introduced, its charms slowly and surely made themselves acknowledged, until now it has permeated every European decorative art manufacture, and notably fabrics, pottery, and printing. This great wave of Japanese influence over the art workshops of Europe is indeed a flattering tribute, and an all-sufficient testimony to the vitality and intelligence of Japanese work, for no mere freak of fashion could have so long held possession of or influenced the direction of European effort. Let me here say that in speaking of European art I always include that of our cousins the Americans. Perhaps in no branch of art education has this shown itself more beneficially than in the greater and juster appreciation of true harmony and juxtaposition of colourings and colour decoration.

When, as the realisation of a long-cherished wish, I found it possible to leave a busy commercial career, and pay a visit to the land which was the birthplace and home of these charming and beneficial influences, I expected to find further mines of unexploited art wealth and a people and nation of artists. I must confess this dream of mine has not been fully realised. Perhaps I am of too sanguine a temperament; doubtless I expected more than in this world of disillusions I was reasonable in expecting. But if I erred in anticipating too great a perfection, I beg you will take it as no unworthy tribute to Japan and its art culture that I should mentally place them upon an impossible pinnacle of perfection. What I seem to have found is this—a whole nation earnest and anxious to secure all the advantages of the new contact with foreign civilisation, shall I say too earnest and too ready to believe in the advantages of foreign civilisation; too ready to undervalue the precious heirlooms of a splendid past. I speak, of course, from the art standpoint, and to that I desire to confine myself exclusively; but I cannot ignore those more material influences which have acted upon, and for the moment bewitched, the art susceptibilities of the nation. I speak, I pray you to understand me, broadly when I say that the great mass of the people have lost their reverence for, and appreciation of, their own beautiful work and their own distinctive art, and have become possessed with a perfect mania for all that is foreign, be it good, bad, or indifferent. I trust I do not offend in thus freely expressing the first impressions that force themselves upon me. I know my opportunities may not have been such as to

warrant my forming an accurate judgment, nor do I claim that judgment, supposing my opportunities have been ample, to be of more value than that of others who have come to no such conclusions. But this I do claim, whether my judgment be right or wrong—I claim to be a sincere lover and appreciator of Japan and its art work, and it is because I do hold myself to be a true and faithful lover that, believing what I do, I will not "cry peace, when there is no peace."

I find, for instance, that in certain of your Government Art Schools pupils are allowed to copy with the aid of tracing paper the drawings on which they are engaged; that the bold sweeping touch of the all-powerful brush is discountenanced by preference for the niggling cross-hatching and hard pencil point; that slavish hand-work reproduction of such a mechanical art as photography is in vogue; that your potters imitate the worst forms of the hybrid class of European pottery, and that they use colouring pigments that are staring, pretentious, and inharmonious; that your cabinet makers reproduce rickety furniture, Europeanised, and worse even than the poor models from which it is copied; that your printers of silken and cotton fabrics indulge in such vulgar and distracting colours for their designs, that one may spend hours vainly looking for something possible to buy; and that your jewellers imitate the trumpery and worst form of production of Birmingham and the Palais Royal. I have seen, too, some of your temples furnished in the new style, with the most hideous patterns in felt carpeting, and badly-carved, pretentious German mirror frames and mirrors usurping the place of the simple and dignified metal mirrors that appropriately belong to such edifices. I find in your houses badly made locks that won't work supplying the place of the delightful and artistic wooden bolts you used to have. I have seen doors, simply because it was an European fashion, made to swing on hinges, instead of slide, so that when opened they completely obstruct the narrow passages; ugly glazed windows with clumsy frames in place of the artistic *shoji*—windows that refuse to open, or, if open, refuse to close; and, what is perhaps even more painful, I find coarsely painted and bad imitations of grained wood used in place of the most delightful varieties of the indigenous woods of Japan. Though perhaps it may be more practical, the new European umbrella, in my opinion, is ugly and misshapen when compared with the Japanese, which covers more space, is cheaper, and with its semi-transparent light adds a charming outline and colour tone around the bearer. Your ladies subject themselves to the iron cruelties of the corset, and to tight-lacing, thus sacrificing the grace and dignity of the free and healthy movement of the classic *kimono*. Such are a few of the results of this undiscriminating anxiety to break away from the venerable traditions and independent civilisation of centuries, and hurriedly adopt foreign manners and customs. I would ask, do you think that this is wisdom? Is it properly exercising your intelligence? Is it paying filial reverence to your great ancestors? I think not, and I think also that the day is not far distant when you yourselves will realise that this is not the method in which civilisation and progress should be made.

And now I desire to speak of the other side of this picture and, in justice, to modify these criticisms, for I know it needs no words of mine to point out to you, who are students of Japanese art, and as such far more keenly aware than a mere stranger of the incongruities which exist. Well, then, I am delighted to add that I have found under this superficial, obtrusive surface distraction, the good, true, old appreciative Japanese art quietly carried on, and as instinct with life as ever; that you have still among you a glorious guild of art workers (and such art patrons as Viscount Sano), workers who equal, if not indeed excel, the traditions of a famous past. Beneath the surface of this superincumbent and self-assertive rubbish heap, there still beats the pulsating life of the old and true art spirit. You have painters of imagination like the recently departed and lamented Kyosai; I will not mention individually the names of those still living. You have excellent masters of the naturalistic school; of the vigorous and characteristic Japanese decorative school; students of the more classical Chinese-Buddhistic school, in which Professor Fenollosa has taken so great an interest. I could indeed enumerate scores of masters' works that I have seen, but I must not be invidious with respect to living artists. But what I have seen is enough and more than enough to prove that the great national painter life is still vigorous among you. And what shall I say when I turn to the art workers? I venture to assert that in the enameller's art the productions of that modest man, Mr. Namikawa, of Kyoto, are more delicately harmonised, more accurately and carefully drawn, and more elegantly finished than any examples of the enameller's art that the world has seen. I venture to say the same also of those most superb, and delicate, and beautiful, and astonishing specimens of needlework produced under the direction of Mr. Nishimura, also at Kyoto—namely, that they are without comparison in the field of the art embroidery of the world. There is no man in Europe who can successfully rival such jewellers and metal workers as Komi and his school, worthy descendants of the celebrated men who made the beautiful and ever wonderful *tsubas*, *kodzukas*, and other armour trappings for your old nobility. In lacquer work my kind friend Viscount Sano has shown me specimens of costly modern work, which, as examples of marvellous gradation in tones of metallic and other colour, spirited and withal accurate drawing, and the wonderful technical skill in the manipulation of the lacquer substance itself, demonstrate beyond question that there are lacquer workers living among you who are as gifted as the great masters of the past. In bronze working, again, many names occur of men under whose magic touch an infinite variety of toned subtle colourings of metals is achieved, which abso-

lutely surpass any ancient work that I have come across, and seem indeed new inventions. Of potters many still carry on the good work and all the excellencies of the past. In wood carving my friend Captain Brinkley has shown me some incredibly wonderful productions. But I have said enough to prove that, after all my fault-finding, I fully believe in the present vitality of the art life of Japan.

Perhaps now you have come to the conclusion that I am somewhat contradicting myself. I hope you have not. What I feel is that the sudden foreign influences which have so materially, and I trust in the main beneficially, affected your country, have as a great wave swept away the old landmarks of Japanese art, so far as regards the ideas of the less thoughtful. Because evident material advantages could be seen in certain things, the conclusion too easily accepted, and indeed too hurriedly rushed to by a great number of the unreflecting, was that everything "foreign" must be good. This, and as I said before, that unceasing hungering in the human mind for everything that is new, simply because it is new, explains to me the reason of these opposing tendencies; on one side the great mass of the unreflecting accepting foreign influence in their arts and manufactures whether it be good or bad; on the other side, a steady silent phalanx treading patiently on in the time-honoured footsteps, firm as a rock in resisting the distraction of all adverse influences. This being so, I look forward to the time when the swing of the pendulum will bring back to the whole people of Japan a more respectful regard for their old arts and art industries.

Art is not of one nation; or of one time, or of one character, nor has she but one face or phase; she is indeed many-sided, and revels in variety. And what an infinite loss it would be to the whole civilised world should those whose opportunities of civilised close seclusion made possible the development of an individual art, peculiar, characteristic, and perfect within its own lines, willingly permit this characteristic art to be swallowed up in the greater monotony of foreign art. European art, most excellent as it is, and in its highest phases perhaps more far-reaching than the art of Japan, has too much lost sight of the beauty of diversity, and runs clothed in plain broadcloth, following the tendency of the rest of the world to obtain an uninteresting level of mechanical perfection.

The day of course has passed when it would be possible or politic to tie down the application of Japanese art only to the ancient uses for which that art was applied. I mean that, for good or evil, European customs, and to a certain extent, a Europeanised style of buildings and mode of living are coming, and will come more and more into vogue. Therefore, and now perhaps for the first time you will say, I begin to be practical—therefore the Japanese lover of art, and the Japanese artist, should strive to see how much of the feeling and tradition of Japanese art can be incorporated in the new form; and whether indeed it be not possible to create objects that shall fulfil the purposes of the new requirements, and shall yet remain essentially Japanese; thought out from the Japanese point of view, and not mere copies of the European object, or a hybrid production, realising neither the usefulness of the one nor the beauty of the other. Japanese art has beneficially influenced the decorative arts of Europe. Do not allow European influence in return to overturn the art of Japan. As an instance of what can be done in preserving the distinctiveness of Japan thought in art work, I would cite the Imperial Palace, which I yesterday had the advantage of being shown over by and through the kindness of Mr. Sannomiya. Here the architect has striven, and on the whole most successfully striven, to preserve the national architectural characteristics, and yet produce an imperial palace fulfilling all the requirements of the altered circumstances. To descend to meaner things. We will take the production of the ordinary opening and shutting fan. We will suppose that the fan is wanted for Western requirements, and is judged by those who order it for commercial purposes to be too small. That being so, the fan can be made larger without in the least departing from the Japanese lines of proportion by keeping to the same lines in the larger as in the smaller one. We will suppose again that it opens too stiffly; it can easily be made to open more freely without departing from Japanese characteristics in the appliances by which this alteration is effected. Suppose further that the substance of which the upper portion of the fan is composed is judged by those who require it to be too solid and opaque; something of a lighter fabric may be substituted, but it must be a Japanese fabric, and thought out on Japanese principles. It may be that for European requirements the conventional forms of Japanese figures or mythological subjects are not approved; birds and flowers can be substituted, but they must be treated in flat decoration, not pictorially, and from the Japanese point of view. I should weary you with many other illustrations, but I think this one simple example conveys the spirit of what I mean, that the product must entirely preserve its Japanese characteristics. Another point I would mention is, that when making goods for foreign trade, such as vases, cabinets, tables, &c., you should recollect the difference of position in which they will be viewed, by reason of the custom of sitting at a higher elevation, and be careful to place your decoration where the new eye level rests; and by all means keep to the free use of the brush, and do not adopt the cramping of the pen and pencil. For foreign use, too, as I hinted before, avoid grotesque figure subjects, because they are not understood by foreigners; paint birds, flowers, fish, and scenery, particularly in the impressionist school. Trays, boxes, and lacquer work should be *adapted* to European requirements, not copies of European shapes. In short, your course should be to comply with European demands by all means, but let

the outcome be still Japanese in character and thought.

It was suggested to me the other day by a Japanese nobleman, whose opinion is of the utmost importance, that the cheapness of production in Japan must of itself make your goods saleable in any market if they be only mere copies of French, Italian, or English models. I venture to think that is not correct. It might, perhaps, be so for some years, but in the long run India or China may come into competition, or you may get ousted by European machinery; so that if Japan rests on the cheapness of her labour she may rest on a false basis. What she should rest on, and what she should be proud to rest on, is the individuality of her own most excellent style.

WINE PRODUCTION IN FRANCE.

The official returns of the last vintage of France show a sensible improvement over that of the previous year. It produced 30,102,151 hectolitres of wine, being an increase of 5,768,867 hectolitres over 1887, and a diminution of 1,601,000 hectolitres only on comparison with the average production of the previous ten years. There were in 1888 1,843,580 hectares under vines. There is an augmentation of production in 37 departments, and a decrease in 40 departments. It is in the southern districts that the improvement is the most marked, whilst the regions of the east and west are most unfavourable. The departments of the south, which were the first attacked by the phylloxera, have been also the first to reconstitute their vineyards by the introduction of American stocks.

These efforts have been in general successful, and in a short time it is hoped this region may regain its former importance. The mildew has in most of these departments been combated by the employment of sulphate of copper. The abundant rains during a portion of the summer and the fine weather which followed in September, contributed to the development of the grapes, and the gathering was effected in excellent conditions. On the contrary, in the colder regions, the persistent rains of summer checked the ripening of the grapes, and retarded the vintage until the approach of frost.

The wine growers had recourse, as in preceding years, to the employment of sugar to improve the quality, and increase the produce of their wines. No less than 36,633 tons of sugar were used for this purpose in 1888. Larger quantities of foreign wines were also imported to meet the demand for mixing. The imports were, from Spain 7,008,000 hectolitres, Italy 1,082,305 hectolitres, and Algeria 1,089,000 hectolitres. The deficiency in the production was also made up by the manufacture of wines from the marc with sugar added, and from dry imported raisins; of the former 2,388,000 hectolitres were made, and of the latter 2,220,000 hectolitres.

The production of wine in Algeria is largely on the increase. The quantity made in 1888 was 2,728,373 hectolitres against 1,902,457 in 1887. There are over 88,326 hectares under culture with vines in Algeria.

EUROPEAN RAILWAY DEVELOPMENT.

L'Economiste Française says that on the 31st December, 1887, the total length of railways worked in Europe amounted to 207,939 kilometres (the kilometre being equivalent to ·621 of a mile), as compared with 201,468 kilometres in the preceding year. The increase in 1887 was therefore 6,471 kilometres, or at the rate of 3·21 per cent. The subjoined Table will show the position of the various countries at the end of each of the years 1886 and 1887:—

Countries.	1886. Kilom.	1887. Kilom.	Increase in 1887. Kilom.
Germany	38,349	39,570	1,221
Austria-Hungary	23,400	24,708	1,308
Belgium	4,534	4,702	168
France	33,343	34,234	891
Great Britain and Ireland	31,375	31,698	323
Russia and Finland	27,698	28,518	820
Italy	11,178	11,616	438
Sweden and Norway	8,839	8,950	111
Denmark	1,965	1,969	4
Spain	9,309	9,492	183
Greece	515	605	90
Netherlands and Luxemburg.	2,858	2,952	94
Portugal	1,529	1,829	300
Roumania	1,939	2,351	412
Servia	444	517	73
Switzerland	2,788	2,823	35
Turkey, Bulgaria, & Roumelia	1,394	1,394	—
Malta	11	11	—
Total	201,468	207,939	6,471

The openings to traffic of the new lines which took place in 1887 increased by 2·67 per cent. the length of the French system, while the per-centage increase was 3·18 in Germany, 5·59 in Austria-Hungary, 3·71 in Belgium, 1·03 only in the United Kingdom, 3 92 in Italy, 2·96 in Russia. Roumanian lines increased 21·25 per cent in 1887. The extent of French railway lines opened in the course of 1887 represents 13·77 per cent. of the total length of line opened in the whole of Europe during the same period. The participation of Germany in the increase of the European railway system is 18·87 per cent.; Austria, 20·21 per cent.; Belgium, 2·60 per cent.; Great Britain and Ireland, 5 per cent.; Italy, 6·76 per cent.; and Russia, 12·67 per cent.

Correspondence.

THE INCREASE OF OPEN SPACES.

The following communication has been received from Mrs. Basil Holmes, Hon. Secretary of the Metropolitan Public Gardens Association:—

The London County Council, as the successor to the Metropolitan Board of Works, has had to undertake the management of nearly 3,000 acres of open space in the metropolis, and is now seeking to increase the number of existing recreation-grounds. The inhabitants of London are waking up to a sense of their need, and there is a growing desire on all sides for public pleasure-grounds to be secured and laid out—a desire which it becomes the duty of the public bodies to satisfy.

The activity of the Open Spaces Committee of the newly-created Council is, I venture to say, greatly due to the past and present exertions of the Metropolitan Public Gardens Association. This Association, during the six and a-half years of its existence, has been hard at work improving and beautifying the metropolis, providing playgrounds and gardens, planting trees and placing seats in thoroughfares, assisting public gymnasia, and fighting to preserve existing open spaces, commons, churchyards, and gardens from the encroachment of railways or buildings. The County Council have chosen as chairman of the Open Spaces Committee, Alderman the Earl of Meath, chairman and founder of the Metropolitan Public Gardens Association, and a large amount of correspondence is constantly taking place between the Council and the Association relative to certain schemes which are on hand for the preservation, provision, and maintenance of open spaces.

Some of the visitors to the Paris Exhibition, though probably only a small proportion of the number, may be interested in seeing in the British Section a huge wall map of London, marked all over with green and red signs, to give an idea of the work accomplished by the Association since it was started. This map shows the successful undertakings of the Association, and some of its unsuccessful attempts to bring health and beauty into the crowded streets. About 200 separate pieces of work have been carried to a satisfactory issue, including the laying out of a park of 14½ acres, 30 public gardens, and 8 playgrounds; the opening on Saturdays of 11 Board School playgrounds; the planting of trees in 20 small churchyards and 14 thoroughfares; the placing of seats in 12 streets; assistance given, by grants of money or seats, towards the formation of 30 public recreation-grounds; grants given to 17 public gymnasia; and successful negociations carried on for the preservation, opening, &c., of 33 open spaces in London and the suburbs.

The benefits of the work are increasing every year, the grounds are becoming more and more valuable to those in whose districts they are situated, and it is only a lack of funds that prevents many more useful schemes from being immediately carried out. Perhaps the clearest sign of the usefulness of this voluntary society is to be found in the effect which its example has had, and is having, upon various public bodies in London, in the provinces, and beyond the seas.

ISABELLA M. HOLMES.

83, Lancaster-gate, W.

SCIENCE OF VENTILATION.

I thought I had sufficiently indicated the nature of the incontrovertible reason, quoted in my last, from a letter published three months ago, why I cannot enter upon discussion with Mr. Buchan, by the reference made to the discussion having "wandered from accuracy on questions of fact."

D. G. HOEY.

Glasgow, 2nd July, 1889.

[This correspondence will now cease.—ED.]

PARCELS POST.

Mr. G. W. FRODSHAM, 4, Change-alley, Cornhill, writes:—

Seeing that the Society of Arts was instrumental in bringing about a postal reform which has proved a great boon to the public at large, I write to ask whether some steps could not be taken by that influential body to introduce a system which has long been prevalent on the continent of Europe and in America, namely, the collection of money due for a parcel of goods delivered, such collection taking place at the actual time of delivery. This is done on the Continent by the Post-office, and in America by a Parcels Forwarding Company. In the latter country the system is so far extended as to render the sending of articles on approval or trial (such as guns, &c.) possible, even to persons who are strangers to the firm sending the goods, the local agents receiving a deposit of the value of the goods during trial, and refunding the same if the trial should not prove satisfactory, less a small charge. Without asking that this latter method should be introduced into our country, it would afford considerably increased facilities to trade were it possible to send goods through the Post-office to persons who had ordered them (through advertisement or recommendation), payment to be received by the *employé* of the Post-office, aud be remitted, less a commission, to the sender of the goods. This system, called in the French-speaking countries *Envoi contre remboursement*, has not, so far as I can learn, given any trouble that is beyond the power of the English Post-office, and would, if introduced, no doubt prove not only a source of revenue to that department, but also afford facilities for trading such as the public would not be slow to take advantage of.

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All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

Proceedings of the Society.

CANTOR LECTURES.

HEAT ENGINES OTHER THAN STEAM.

By H. Graham Harris, M.Inst.C.E.

Lecture I. — Delivered May 6th, 1889.

(Continued from p. 693.)

The theory of working of heat engines is indissolubly connected with the name of a Frenchman, an ancestor of the present President of the French Republic (M. Carnot).

In 1824, M. Carnot published his work, entitled "Reflexions sur la Puissance Motrice de Feu," in which he enunciated the natural law known by his name. M. Carnot was one of those who at this time held the "caloric" theory, as it was termed, that is to say, he believed that heat was a material substance; he had not then realised the dynamical theory of heat, *i.e.*, that heat and motion are convertible, which is now, as I have said, universally accepted, and, therefore, although the theory as he propounded it is true, yet in some of his deductions he has since been proved to be incorrect.

You will notice, during our consideration of it, that it is hedged completely round with specified conditions, and you will frequently find (even in some of the text-books, I am sorry to say) that some one or more of these conditions is neglected or eliminated, with the result that absolutely fallacious arguments are propounded.

Carnot based his arguments on a fact which we all intuitively feel to be true, that given two bodies of different temperature in proximity the one to the other, there is a continual tendency towards the establishment of equilibrium of temperature between them. Further, he pointed out that this tendency is an invariable accompaniment of the conversion of heat into motion; and he stated (that which is obvious, if these previous statements of his are correct) that whenever there is a difference of temperature it should be possible to obtain production of motion.

The doctrine of Carnot may be roughly defined in this way. The utmost work which can be obtained from a theoretically perfect heat engine (when the working agent does not change its state, as from steam to water) is represented by the difference between the temperature at which the working agent is received into this ideally perfect engine, and that at which the working agent leaves the engine.

Carnot himself illustrated his proposition by comparing it to the power produced by a fall of water acting on a water-wheel. I have here upon the wall a diagram used by Mr. William Anderson, in the lectures to which I have already referred, and you have a reduction of this (Fig. 3, p. 700) among the illustrations which have been handed to you. This shows graphically what was suggested by Carnot.

You will see at the top of the hill, on the left-hand side of the diagram, a reservoir of water connected by a pipe running down the hill to a turbine placed in a small house half-way down; and you will also see that a channel is carried from the tail-water of this turbine further on down the hill, till it connects with the sea at the bottom.

Now it is evident that the only power which could be utilised to work the turbine, if the water could not fall to a lower level than that of the tail-water at the turbine itself, would be that due to the weight of water falling from the top of the hill to the level of the tail-water at the turbine, and assuming that there is no friction in the pipes, or losses in any way whatever, then the whole of the power residing in this weight of water, falling through the height shown, might be obtained.

Now if you had another pipe, from the same reservoir at the top of the hill, carried to a turbine placed at the sea level, and arranged so that it could deliver its tail-water there, it is evident that the power that could then be obtained would be greater than before, because of the greater height through which the water could fall. Now assume that the water in the

top reservoir is represented by T, or highest temperature, and that the water at the sea level is represented by *t*, or lowest temperature, it is evident that the power to be obtained would be that due to the weight of water falling per minute, say W, multiplied by the difference in height between T and *t*, or if the tail-water at the turbine, which is shown half-way down the hill, is represented by *t* 1 then the proportion of the total work which could be obtained from a turbine placed here, would be represented by the proportion which the height T, minus *t* 1, bears to the total height, T, the weight of water falling being the same in both cases; or, in other words, calling the water heat, then the total quantity of work to be got out of a perfect heat engine, is represented by the difference between the incoming temperature, T, of the working agent, and its outgoing temperature, *t* or *t* 1, as the case may be.

It is further obvious that the higher the incoming temperature, or the lower the outgoing temperature, the greater will be the difference between them, and the greater the total possible work which will be obtainable from the ideal engine, and also that the only way of obtaining the total possible result from any given working agent in a perfect heat engine is to have the incoming temperature at the highest, and to reduce the outgoing temperature to the lowest possible point. I shall have again to refer to this question of the lowest possible

Fig. 3.

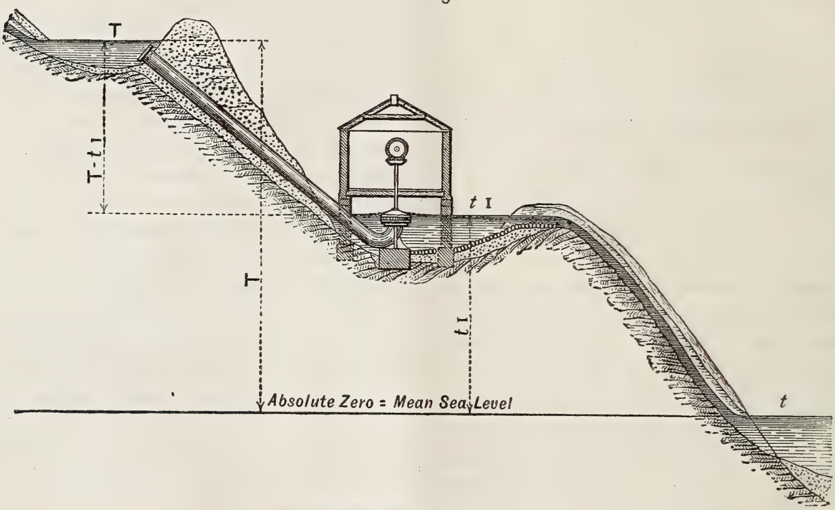


Illustration of Carnot's Theory.

temperature almost directly, in connection with what is known as "the absolute zero of temperature."

You will see also that if we had an ideal or perfect engine, which would utilise the whole of the difference between the incoming and outgoing temperatures of the working agent, not losing any heat in any way whatever, and also that if mechanical work is produced by the transformation of the heat in one body into motion in another, and not by the dissipation of the heat, then it should be possible to renew the heat by passing it through another engine, which should be worked by the first, and should take in the working agent at the lower temperature at which it would be rejected from the first engine, and should discharge it at the higher temperature it originally had, ready to be again taken into the first engine to be transformed into work there. The work in the two ideal engines would be absolutely equal, and the working agent would pass through a perfect "cycle" of operations, that is to say, would commence at the highest and would go to the lowest temperature, and from that again to the highest temperature, the heat being first transformed into mechanical work, and then this work re-transformed into heat.

The perfect or ideal engine, therefore, must be, according to the Carnot theory, absolutely and entirely reversible; but, let us see some of the impossibilities, in practice, this theoretically perfect engine involves.

First, we should need for the working agent a perfect gas, the volume, and therefore the pressure, of which would vary exactly as the temperature. We should also need an engine absorbing for itself no portion of the work developed, that is to say, a frictionless engine, and one also in which none of the heat imparted to the working agent was lost either by radiation or conduction, or, in fact, in any way whatever—as I have said, impossibilities.

I commenced by showing you these cubes, the black one representing a definite quantity of heat, and this smaller red one representing the amount of that heat utilised in practice in a very fair high-pressure compound non-condensing steam engine of the present day. But you will now realise that, as no mechanical combination can possess the impossible qualities which we have seen must be possessed by an ideal engine, we are really not treating our steam engine fairly in making this comparison, unless we bear the above impossibilities in mind. Of course, this reasoning applies equally to the gas engine and to the gas-engine cube.

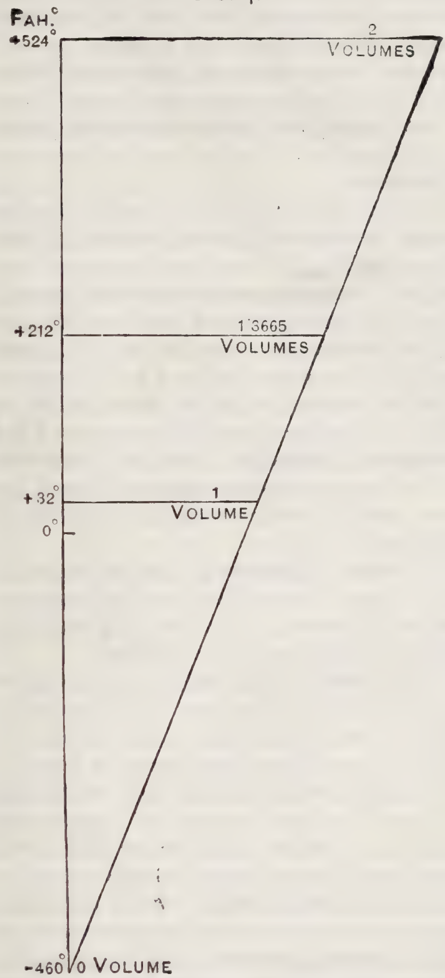
In order to utilise to the utmost the quantity of heat represented by this black cube, we should require that that heat should be delivered to the engine at the highest possible temperature which can be attained, and we should require to take all the heat out of it, so that when we rejected the working agent from our engine, it would be at the lowest possible temperature.

As to this question of the lowest possible temperature; I have already shown you that the addition of heat to a gas causes the volume of that gas to increase if the pressure remains constant. Now, if we can imagine the reverse of this process carried on sufficiently far, we can realise that the volume of the gas will be infinitely reduced, so that when the whole of the heat has been abstracted from it, it would have entirely disappeared. We should then reach that which is called the "absolute zero of temperature."

Let me illustrate this to you. Let me ask you to look at Fig. 4, which is among the illustrations you have.

It has been proved that air or any similar gas expands by 1-492nd of its bulk for each additional degree of temperature, if the pressure is kept constant; that is to say, if we increase the temperature of a gas by 492°, its volume will be doubled. Now if you will look at the diagram you will see on the left-hand side the vertical line representing the temperature, and you will see the horizontal ordinate, at 32°, representing the volume of the gas at that temperature as one. If we now increase the temperature by 492°—that is to say, up to 32° + 492° = 524°—the volume will be doubled, or will become two. Now, if we join the two points, we shall find that at 212°, or at boiling point of water, the volume would be 1·3665,

Fig. 4.



Absolute Zero of Temperature.

but if we carry the sloping line joining these points on downwards till it cuts the vertical line, it will do so at a point which represents a temperature on that vertical line of −460°, or 460° below zero, equal to 460° + 32° below freezing point, and this point of −460° is called the "absolute zero of temperature."

I have purposely neglected the small fraction of a degree, which would only complicate our

illustration, the fact being that the correct absolute zero is only $-459·13°$, and not $-460°$, but for all practical purposes the $-460°$ is sufficiently near, and is generally used.

You will see, therefore, the assumption is, that if in an air thermometer a reading could be taken showing such a degree of temperature, we should find that the volume of the air had been reduced infinitely. Professor Clerk Maxwell, however, points out that it is almost certain, even at this temperature, the air would occupy some space, and that we can only imagine the effect of such a degree of cold, and can know absolutely nothing definitely about it. As yet, temperatures of $-220°$ Fahr., or 220° below zero, are, it is said, the lowest which have been obtained even in laboratory experiments.

The text with which I commenced to-night adopts the steam engine as a standard of comparison of the relative advantages of heat engines. It is necessary we should have something that we can grasp and readily understand to base our comparison on, and we will, therefore, take the steam engine for this purpose. It is that heat engine which is most largely in use, which has been most fully considered and investigated, although there are some who tell us that we, even now, know nothing of the more abstruse points in connection with its working.

I do not at all propose to discuss this, or to delay about it, but will only use, for our comparison, the record of the practical results in efficiency which have been obtained.

Unfortunately, in taking the steam engine as our basis, we are met with the initial difficulty that such an apparatus consists, as a fact, of two distinct and separate forms of heat engine, each with its own mechanical efficiency, or rather want of mechanical efficiency. Perhaps it will be as well that I should now define precisely what is meant by "mechanical efficiency." It is that percentage of the units of heat put into an engine, which is utilised by it, *i.e.*, that proportion of the total heat units, which is transposed by the machine into mechanical work, or delivered from it in such a state as to be capable of doing mechanical work.

I have already told you that a "heat unit" is the amount of heat necessary to raise 1 lb. of water 1° Fahr. There is one more term which I shall have to define, and that is the one used by engineers when they speak of the work performed by an engine. They say it is so many "horse-power."

James Watt adopted this term horse-power in order to give the lay mind some idea of the work which could be done by any given engine or machine. He made many experiments as to the amount of work which a horse was capable of doing, with the result that when this work was reduced to that which was equivalent to the raising of a weight in a given time, he found that the average horse could do as much work as was represented by lifting a weight of 22,000 lbs., there or thereabouts, through a height of 1 foot in 1 minute of time; but so that his customers should not grumble, complaining that the engines with which he supplied them were not capable of doing as much as the number of horses which he stated was the power of the engine which he sold them, he determined to give an ample margin, and he therefore estimated each horse-power in his engines as represented by a weight of 33,000 lbs. (an excess over the true value stated above of 50 per cent.), lifted 1 foot high in 1 minute of time, or 33,000 foot-pounds. This is the horse-power which the engineer commonly uses, and of which I shall have, frequently, to speak.

Now, as I have shown you that heat is convertible into mechanical work, it follows that a heat unit can be represented by some proportion of a horse-power.

If you will remember the experiments by which Count Rumford proved that heat and mechanical work were convertible, you will realise that it would have been possible to have obtained from these some equivalent which should represent exactly the quantity of heat in a given amount of mechanical work.

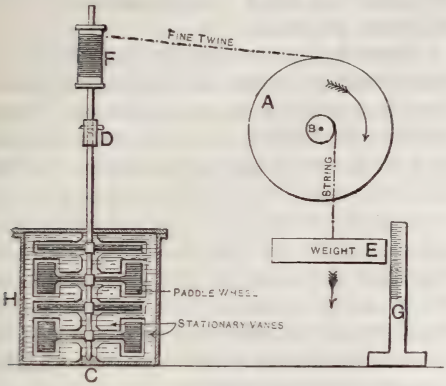
With this question of the mechanical equivalent of heat, the names of Mayer—a German scientist—and Dr. Joule are inseparably connected. About the year 1842, each of them published (Mayer as the result of calculations, and Joule as the result of experiment) a statement as to the value of the mechanical equivalent of heat.

In the year 1849, Dr. Joule, when he had been experimenting for over seven years, read a paper before the Royal Society, in which he stated that he considered it important that the relations between work and heat should be definitely ascertained, and with absolute accuracy, or, in other words that that which we now speak of as the mechanical equivalent of heat, or perhaps, more commonly as Joule's equivalent, should be ascertained with absolute certainty. He proceeded to describe the experimental apparatus which he

had devised and employed for the purpose of discovering the true value of this, also describing the method of using this apparatus which he had adopted.

Shortly stated, it consisted of a series of revolving paddles (see Fig. 5) placed in a

FIG. 5.



JOULE'S EXPERIMENTAL APPARATUS.

closed vessel containing a definite amount of water, at a given temperature, these paddles being caused to revolve in the water (and thus to churn it as it were) by means of cords passing over pulleys actuated by a falling weight, or weights. Repeated experiments were made, and, as a result, it was found that a weight of 772 lbs., when falling through a distance of 1 foot, would increase the temperature of 1 lb. of water 1° Fahr. Precautions were taken to measure exactly the loss of heat by radiation and conduction, and every circumstance which could possibly affect the result was taken into consideration. Dr. Joule's communication of this date to the Royal Society winds up with the following conclusions:—

1. The quantity of heat produced by the friction of bodies, whether solid or liquid, is always proportional to the force expended.

2. The quantity of heat capable of increasing the temperature of 1 lb. of water (weighed *in vacuo*, and taken at between 55° and 60° Fahr.) by 1° Fahr., requires for its evolution the expenditure of a mechanical force represented by the fall of 772 lbs. through the space of 1 foot.

Please remember, therefore, that the mechanical value of a British heat unit is always taken as representing 772 lbs. weight lifted 1 foot high, or falling through the same distance, and that this is known as Joule's equivalent.

It follows, from what I have just said, that Joule's equivalent being 772 lbs. lifted 1 foot per minute, or 772 foot-pounds, and the indicated horse-power being 33,000 foot-pounds, $42\frac{3}{4}$ heat units expended per minute, or 2,565 heat units per hour, is the equivalent of an *indicated* horse-power. You will notice that I use the term "*indicated* horse-power," emphasising the *indicated*.

You all of you know that the engineer is nothing if not accurate. I am sorry to have to say it, but the accurate engineer has no less than five forms of horse-power of which he speaks, and unless you pin him down to telling you exactly what horse-power he means—whether indicated horse-power, or brake horse-power, or nominal horse-power, or whatever it may be—he will most likely succeed in confusing you, and probably himself. Mr. Preece and other electricians now want to put another sort of horse-power upon the unhappy engineer, and they want him to have and to use a special electrical horse-power. However, I do not wish to trouble you with any of these other kinds of horse-power; I always propose, in these lectures at least, to speak of indicated horse-power, that is, horse-power developed in the cylinder, and capable of being shown by the indicator on the indicator diagram, which I shall have presently to describe.

Now, the best Welsh steam coal has been proved by frequent analysis to contain combustible material which, when burnt to destruction, would be capable of developing about 14,500 heat units for each 1 lb. weight of coal; therefore, as 2,565 heat units per hour equal 1 horse-power, it follows this should, theoretically, be obtained for ·17, or 17-100ths of 1 lb. of such coal consumed per hour. This would be the consumption in the ideal engine; but this, as I have shown you, is an impossible machine.

Here is another instance of the lucidity, the simplicity of statement, adopted by the engineer. You will see that he states his horse-power as pounds weight lifted 1 foot high in a *minute* of time, while he talks of his fuel consumption as that used per horse-power in an *hour* of time.

Referring to our cubes again, this red cube represents the fuel utilised by a steam engine consuming practically the smallest quantity of fuel, of which there are absolutely certain records, and you will see that the horse-power there is only obtained for about $1\frac{1}{2}$ lbs., or 150-100ths, instead of 17-100ths of 1 lb. of coal, and that the mechanical efficiency,

therefore, is not quite 1·9th, or practically about 11 per cent.

Let me once more say that I am not suggesting for a moment the possibility of realising the ideal steam engine. Remember, that in order to utilise the whole of the fuel, or, in other words, to obtain an indicated horse-power for 17-100ths of 1 lb. of coal per hour, you would, among other impossible things, require steam of a temperature, and of a pressure, such as would make its density equal to that of water; while the products of combustion of the fuel which had raised the steam to this temperature must escape at the temperature of the atmosphere, and the steam must be expanded to such an extent as to bring it down to the absolute zero of temperature.

I have told you that the initial difficulty in taking the steam engine as our basis of comparison is, that it really consists of two distinct and separate forms of heat engine—the one the boiler, the other the engine itself.

Let me now show you what is really the efficiency of the engine alone and without the boiler. Look at this black cube again, and assume that it now represents the amount of heat units which are supplied to an engine using some 18 lbs. of water per horse-power hour, delivered to it from the boiler in the form of steam, at 150 lbs. pressure, the steam exhausting from the engine, or leaving it at the pressure of the atmosphere, and therefore at a temperature of 212°. Now, this other red cube, which represents the efficiency of such an engine, is, as you will see, much larger in proportion to the black cube, representing the heat delivered to it, than was the red cube of the efficiency of the engine and boiler combined.

These cubes represent the fuel and efficiency of such an engine and such a boiler as those tried by the judges at the Royal Agricultural Society's Show at Newcastle in 1887, or at the electric motor trials of this Society. In fact, they may be called very fair, or even exceptionally good examples of the ordinary commercial high-pressure compound non-condensing engine. The efficiency of the modern quadruple expansion marine engine is slightly greater than this, but not so much so as to affect the argument which I shall base upon these cubes.

I have purposely shown you the efficiency of the engine and of the boiler combined, and then that of the engine alone, because, as I shall have to tell you again later on, almost all of the "heat engines other than steam" are engines in which the boiler, or its equivalent, is entirely absent, and in which the heat is produced in the cylinder of the engine itself; and I am prepared to suggest that, to some extent, the efficiency of these other heat engines is due to the fact of the absence of the equivalent of the boiler, and to the fact that the heat is developed in the engine cylinder itself, and that there is no separate vessel in which it is produced.

I know that there may be quoted against this statement the fact of Watt's great invention—that of the separate condenser. Here, increase of efficiency was obtained by utilising the heat in two vessels in succession, instead of in one, and I may also be referred to the increase of efficiency in marine and other engines, due to the use of the triple, or even quadruple cylinders, in which, in succession, the steam is expanded, but I think a little consideration will show that an increase in the number of vessels in which the heat is utilised, is not an advantage, *per se*.

Further, we shall find that one of the most promising suggestions for the improvement of these other heat engines is that the number of cylinders in which the working agent is used in succession shall be increased, *i.e.*, that the engine shall be made compound, or even triple compound. But you will see that these additional cylinders are intended to utilise the heat which is at present lost by passing away in the exhaust, or, in other words, the object is to increase the range of the temperature through which the engine works, not by adding to that which is initially developed, but by utilising a portion of that which is at present thrown away.

Having now stated to you, pretty fully, the nature of the theory of working of the steam engine, and having done this because it is used in my text, I would like to still further clear the ground—although I may be accused of being very elementary—by spending a few minutes on the question of expansion in a heat engine.

In order not to overload more than is necessary the theoretical portion of our subject, I have, up to the present, simply spoken to you of expansion, telling you that expansion is the basis of all economical working of heat engines. I also showed you a diagram, representing the expansion curve of the work done when a big gun is fired—one of the simplest cases of expansive working.

Let us see how expansion operates in a steam engine. You all know that the principal

portion of a steam engine consists of the vessel called the cylinder, this being the vessel in which the work is developed; you know also that this is a truly cylindrical vessel of a given length, in which a piston, or disc, is caused to work backwards and forwards by the pressure of the steam which passes alternately into either end of the cylinder, between the covers and the moving piston. From the piston a rod proceeds, working steam-tight through a stuffing box in one of the covers. To this rod a jointed rod is attached, which transposes the reciprocating motion of the piston into the rotary motion of the crank shaft.

Figs. 6 to 9 show by the thick, black lines of Fig. 6 a section through such a cylinder. At the left-hand end of this you see the piston, with the piston rod proceeding from it, towards and through the cover at the right-hand end; the rod passing through a stuffing-box in this cover, to keep it tight against the pressure, and thus to prevent leakage of steam.

In Fig. 7 you will see a square which is shaded, or hatch-lined. Now this square, represents, by its length, the portion of the stroke, or the distance through which the piston has travelled, and by its height above the base line at any point, represents the pressure existing at that point, say in pounds, per square inch. You will remember the diagram of the big gun was shown in a similar way. This square diagram, therefore, tells us that the piston has moved from end to end of the cylinder, and that while it has done this, the pressure existing in the cylinder has been uniform and at a maximum—that is to say, there has been no expansion. You will see there is stated on the diagram that the ratio of steam used to work done is as 100 to 100.

If you look at the next diagram, Fig. 8, you will see that it is only of the full height for half its length, and that at that point the upper line begins to fall—that is to say, the pressure begins to decrease, and goes on decreasing, following a uniform curve until the end of the cylinder is reached, when the pressure is at its lowest. This diagram would tell us that the steam, or other working agent, had been maintained at the pressure at which it was admitted to the cylinder for half the length of the stroke of the piston, that then the inflow of the working agent had been stopped, and that which was in the cylinder had been allowed to expand, and had thereby become increased in volume, decreased in pressure, losing some of its heat in the process, because of the work which it had done in expanding and pushing the piston forward, as was done by the powder to the shot. Upon the diagram the advantage to be obtained by this expansion—that is to say, the ratio of steam used to work done—is stated as 100 to 169.

Fig. 6.—Elementary Cylinder of Heat-engine.

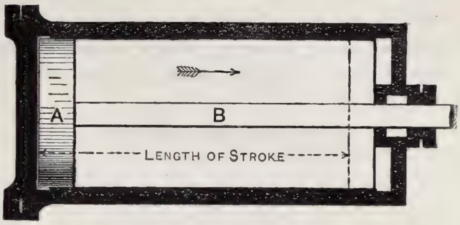
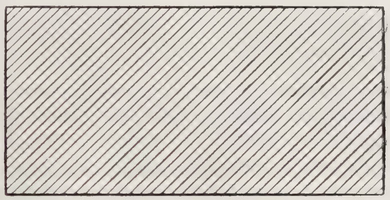
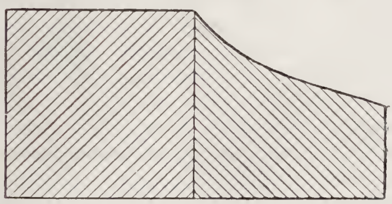


Fig. 7.



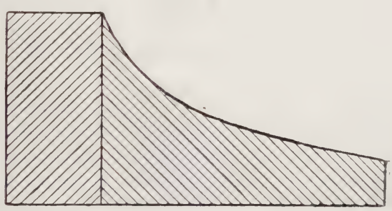
Steam used throughout the whole stroke. Ratio of steam used to work done, 100 : 100.

Fig. 8.



Steam cut off at one half stroke. Ratio of steam used to work done, 100 : 169·2.

Fig. 9.



Steam cut off at one quarter stroke. Ratio of steam used to work done, 100 : 238·4.

In the next of these diagrams, Fig. 9, the same principle has been illustrated, but here it is supposed that the inflow of the working agent at its full pressure has been stopped

when the piston has moved through a quarter of its stroke, the remaining three-quarters being done by expansion.

You will see that the right-hand end of this diagram is much lower than the right-hand end of the diagram above it, *i.e.*, the pressure has fallen in this case lower, more work having been done; more heat having been abstracted. And look what has been the result of cutting off the inflow of the working agent as early as one quarter of the stroke. Here the ratio of steam used to work done is as 100 to 238·4.

Miscellaneous.

INDUSTRIAL AND PROFESSIONAL EDUCATION IN BELGIUM.

Much attention is given to technical education in Belgium by the State and cities, and this is given in workshops for apprentices, in industrial schools, and professional schools for girls and boys.

The workshops for apprentices are chiefly confined to youths in the country who devote a part of their time to weaving linen, or other work, such as carpets and common stuffs, according to the localities where the schools are established. There are forty-five of these schools of apprenticeship in West Flanders, and nine in East Flanders. A superintendent or director is attached to each, who, besides giving practical information as to work, is equally bound to give theoretical information on the art of weaving, all kinds of fabrics being successively studied. The object of the industrial schools is to give to the workmen that scientific instruction which he could not acquire in the workshop, and thus give him the means of bettering his condition, developing his intelligence, by initiating him into the general laws which belong to the transformation of materials, thus taking him out of the mere trammels of routine, increasing the economic value of his work, and enabling him to increase production and enhance his wages.

These schools are intended to promote elementary scientific education. No manual occupation is given; these are assumed to be acquired by the apprentice in in the workshop. There are about thirty-five of these schools subsidised by the State. The programme of study includes the general notions of calculation, perspective, geometry, freehand drawing, designing ornaments and solids. The elements of physics and mechanics, hygiene, and industrial economy, special studies on chemistry, mining, metallurgy, and civil construction are given in different schools, according to the requirements of the locality. The term of this education is three years, but sometimes they extend to four years. On passing an examination the workman obtains a diploma or certificate, which, while certifying their skill, entitles them at the same time to an electoral vote. The professional schools are of two classes, for girls and boys. A part of the time is devoted to theoretical study, and a part to practical hand work. The female scholars choose the work they have the most aptitude for, which includes painting on porcelain, silk, fans, and glass, the designing of lace work, the cutting and making up garments, sewing and embroidering, the manufacture of artificial flowers, and commercial pursuits.

A special diploma can be obtained in each class after three years' apprenticeship. The scholars pay a slight contribution, and there are some free scholarships. The State subsidises five of these schools, and the results obtained are very satisfactory. The professional schools for boys comprise the following:—Watch and clock work at Brussels; one for tailors in Brussels and one at Liege; a school for brewers at Ghent; weaving schools at Ghent, St. Nicolas, Courtrai, and Verviers; a typographical school for compositors and printers at Brussels; one for millers at Louvain; one for a knowledge of steam-engines at Namur; schools for the study of electricity at Brussels, Ghent, Charleroi, and Liege; schools for photography at Brussels and Ghent; one for working in wood and iron at Ghent.

In the two first-named schools, for horology and tailors, payments alone are made, as the pupils remain at work all day; and the sons of brewers pay, but the workmen receive instruction free. In the professional schools there are 3,374 scholars, and in the industrial nearly 11,000. The total subsidy for industrial schools is about £21,000, and for the professional schools over £12,000. From one-third to one-half of the subsidy is paid by the State, the rest by the commune and province.

THE COAL INDUSTRY IN FRANCE.

The French Ministry of Public Works has recently published its annual volume entitled *Statistique de l'Industrie Minérale et des Appareils a vapeur en France et en Algerie* for 1886, from which it appears that the quantity of coal produced in the country amounted to 19,909,894 tons; in 1887 it amounted to 21,288,000 tons, and the provisional returns for 1888 give it as 22,952,000 tons. In the course of the year 1886 there were three coal concessions granted, one in the department of the Tarn, and the two others in the Haute Loire. On the 1st January, 1887, there were 639 coal concessions in France, representing an area of 568,607 hectares (the hectare is equivalent to 2·47 acres). In Algeria there was one concession, with an area of 945 hectares. The richest departments in concessions are not the most

productive; for example, while the Loire heads the list with 72 concessions, followed by the Gard with 57, by Aveyron with 41, and the Hautes Alpes is found to possess 49, Savoie 45, and Isère 42, the departments of the Nord and the Pas de Calais only take the ninth and tenth places with 21 and 22 concessions respectively. The following tabular statement shows the production and consumption of coal in France at various periods since 1815:—

Years.	Production.	Consumption.
	Tons.	Tons.
1815..........	881,587	1,112,194
1825..........	1,491,381	1,994,385
1835..........	2,506,416	3,288,238
1845..........	4,202,091	6,343,069
1855..........	7,453,047	12,293,686
1860..........	8,309,622	14,270,252
1865..........	11,652,755	18,522,375
1870..........	13,179,788	18,830,038
1875..........	16,956,840	24,657,530
1880..........	18,804,767	28,846,300
1881..........	19,765,983	29,444,900
1882..........	20,603,704	31,024,600
1883..........	21,333,884	32,439,900
1884..........	20,023,514	30,941,400
1885..........	19,510,530	30,034,800
1886..........	19,909,894	29,724,000
1887..........	21,288,000	31,191,000
1888..........	22,952,000*	—

* Provisional figures.

In 1886, the latest year for which reliable details are given in the *Statistique de l'Industrie Minérale*, the total coal production, viz., 19,909,894 tons, is made up of 19,454,127 tons of anthracite and 455,767 tons of lignite. The departments in which coal was worked numbered 40, as compared with 42 in the preceding year; in 16 of these only the production exceeded 100,000 tons. Of these, the Pas-de-Calais, Nord, Loire, Gard, Saône et Loire, Allier, Aveyron, and the Bouches-du-Rhône contributed 17,963,000 tons, or nearly nine-tenths of the total production, as follows:—Pas-de-Calais, 6,463,000 tons; Nord, 3,910,000; Loire, 2,788,000; Gard, 1,712,000; Saône et Loire, 1,240,000; Allier, 801,000; Aveyron, 661,000; and the Bouches-du-Rhône, 388,000. As compared with the preceding year, the Basin of the Nord, and the Pas-de-Calais (Valenciennes) showed the largest increase, namely, 663,000 tons; next in order come the basin of the Bourbonnais, with 67,000 tons; Provence, with 17,000 of lignite; and the basin of the Gard with 11,000 tons. On the other hand, there is a falling off to the extent of 169,000 tons in the basin of the Loire; 116,000 tons in the basin of the Tarn and Aveyron; 30,000 tons in the Western Vosges; and 20,000 tons in Burgundy and Nivernais. As regards the basin of Valenciennes, the report states that the increase in the production appears to denote a decided improvement in the industrial condition of the north of France, and to this improvement the lowering of the tariffs of the Northern and Eastern Railway Companies has to some extent contributed. The following Table will show the quantity of coal imported into France for each year comprised within the decennial period 1877-1886, from the three principal coal-producing countries:—

Years.	Belgium.	United Kingdom.	Germany.
	Tons.	Tons.	Tons.
1877....	3,875,000	2,867,000	1,137,000
1878....	4,364,000	2,794,000	1,041,000
1879....	4,820,000	3,012,000	1,047,000
1880....	5,277,000	3,404,000	1,259,000
1881....	5,396,000	3,569,000	1,255,000
1882....	5,570,000	3,884,000	1,408,000
1883....	5,756,000	4,368,000	1,577,000
1884....	5,733,000	4,259,000	1,678,000
1885....	5,321,000	4,079,000	1,511,000
1886....	5,086,000	3,921,000	1,368,000

The proportional share of the imports in 1886 was 49 per cent. for Belgium, 38 per cent. for the United Kingdom, and 13 per cent. for Germany. The exports in 1886 amounted to 531,000 tons, an increase of 19,000 over the preceding year. This increase came principally from the basins of the Gard, Valenciennes, Loire, Creusot, Blanzy, Bonchamp, and Fuveau, the last two contributing lignite. It was chiefly to Italy, Belgium, and Switzerland that these exports were directed. The consumption of coal rose in 1886 to 29,619,000 tons. The average value of coal at the pit's mouth was as follows:—Valenciennes, 9f. 82c.; Loire, 13f. 94c.; Gard, 12f. 32c.; Bourgoyne and Neurnais, 12f. 96c.; Tarn and Aveyron, 11f. 12c.; Bourbonnais, 11f. 40c.; Provence, 9f. 71c.; and other basins, 13f. 68c. The general average price was 11f. 19c. per ton, a falling off of 54 centimes compared with the preceding year. At the place of consumption the average value per ton amounts to 19f. 79c. a diminution of 1f. 10c. The following seven departments are the largest consumers of coal:—Nord, 5,188,000 tons; Seine, 3,066,000; Pas-de-Calais, 2,005,000; Meurthe-et-Moselle, 1,733,000; Loire, 1,236,000; Seine Inférieure, 1,177,000; and Bouches-du-Rhône, 1,070,000 tons. Then follow the departments of the Aisne, Rhône, Saône et Loire, Somme, Gard, Seine et Oise, Allier, and Ardennes. The number of persons employed in coal mining amounted to 102,354, distributed as follows:—Below ground, 68,248 men, and 4,538 children under sixteen years of age, making a total of 72,786; above ground, 23,046 men, 3,258 women, and 3,264 children under sixteen—making in all 29,568 workpeople of all

ages and both sexes. Wages paid in the coal industry amounted to 107,363,000 francs, and the average daily wage, without distinction of age or sex, was 3f. 71c. Independently of the wages properly so called, the miners receive assistance in money or kind, as well as medical care in the case of injury or illness; in addition, they receive in some collieries grants of coal, either free or at reduced prices, and find, in the workmen's communities established by many proprietors, lodgings at a very cheap rate. The following Table shows the annual production by each miner, and the total amount of wages paid for each ton of coal extracted:—

Basins.	Production.	Wages.
	Tons.	fr. c.
Valenciennes	230	4·66
Loire	197	5·51
Gard	162	7·00
Creusot et Blanzy	176	6·68
Aubin et Carmaux	171	5·83
Commentry	185	4·80
Provence	164	6·10

The proportion of deaths by accidents in 1886 was in the ratio of 16·1 per 10,000 miners employed. In addition to the above information respecting the coal industry in France, some particulars are given in the *Statisque de l'Industrie Minérale* on the subject of the discoveries of phosphate of lime. It appears from the report that the extent of the beds discovered up to the present time is estimated at nearly 30,000 hectares, distributed over twenty-one departments. They are stated to contain 32,500,000 tons of workable phosphates, situated generally at a very slight depth below the surface, and capable of being easily worked. "A subterranean source of wealth," says the *Statistique*, "representing in value a sum exceeding 1,000,000,000 francs."

PRODUCTION OF COTTON-SEED OIL IN THE UNITED STATES.

Cotton-seed oil is obtained from the seeds of the *Gossypium herbaceum*, and the per-centage of oil varies in the seed from 10 to 30. From a report recently issued by the United States Government, it appears that from September 1st, 1883, to September 1st, 1886, there were exported from New York 88,871 barrels, and from New Orleans 186,720 barrels, making a total of 275,591 barrels from the two ports. The following is the method adopted in its preparation. The seed, when landed at the mill, is first examined. If too damp or wet, it is dried by spreading it over a floor with free access of air, exposing it on frames to the sunlight in warm weather, or by kiln drying. Drying is the exception rather than the rule in the United States. Cotton ginning is so carefully done that the seeds have little or no opportunity to become wet. Besides this, the seed is generally held at the gins for some time before it is sold to the oil manufacturer. The first process in preparing the dry seed for the mill is to free it from dust. This is effected by shaking it in a screen, or in drums lined with a fine metallic net, and containing a strong magnet, to which any iron nails will adhere, these articles being frequently present. From the drums the seeds drop into a gutter, leading to a machine which removes the lint left by the gin. This is done by a gin constructed for the purpose, with saws closer together than the ordinary cotton gin. An average of 22 lbs. of short lint is taken from a ton of the seed. This product, called "linters," is used in the manufacture of cotton batting. The clean seeds are then transferred to the sheller, which consists of a revolving cylinder, containing twenty-four cylindrical knives and four back knives. The sheller revolves at great speed, and as the seed is forced between the knives the pericarp or hull is broken and forced from the kernel. The mixed shells and kernels are separated in a winnowing machine by a strong blast of air. This removal of the husk makes a considerable difference in the meal cake, a dessicated or decorticated cake being, it is said, five times more nutritious and wholesome than an undecorticated cake. Being thus cleaned, shelled, and separated, the kernels are carried by a system of elevators to the upper story, and then pass down into the crusher rolls to be ground to flour. Cold pressure produces a very good salad oil, and this is the method generally pursued in Marseilles and other European cities for the first pressure, after which the residue is subjected to a second warm pressure. In the United States, however, warm pressure is generally preferred. The meal is heated in a meal-heater for fifteen to twenty minutes to 204° to 215° Fahr. The heated meal is placed in woollen bags, each holding sufficient seed for a cake. The bags are then placed between horsehair mats backed with leather, having a fluted surface inside, to facilitate the escape of the oil under the hydraulic pressure, amounting to 169 tons. With the most improved presses the hair mats are now, however, done away with. The bags remain in the press seventeen minutes, the solid oilcake of commerce remaining behind. This cake forms a superior food for cattle, horses, sheep, and swine, and is nutritious, easily digested, and fattening. The crude oil, as obtained from the press, is pumped into the oil-room, and either put into barrels for shipment, or refined. There are four qualities of the oil. Crude oil is a thicky fluid, and of a dirty yellow to reddish colour; on standing, it deposits a slimy sediment. The second quality has a pale orange colour and is obtained by refining the crude oil, which is done as follows:—After weighing, the oil is pumped into refining kettles. These are of various sizes, the largest ones being 20 to 25 feet deep, and 15 feet in diameter. These tanks are furnished with steam

coils for the purpose of heating the oil, and with appropriate machinery for keeping it in motion. A solution of caustic soda is used for refining; this solution is made from 10° to 28° Beaumé in strength, and varying quantities are used, according to the nature of the oil operated upon. After the addition of the caustic soda, the mixture is stirred up for 45 minutes, and kept at a temperature of 100° to 110° Fahr. The contents of the tank are then allowed to stand from 6 to 35 hours when the solid matters — soap and substances precipitated by the caustic alkali — gather on the bottom. This mixture is called "foots," and is used for making soap. The yellow oil resulting by this process is further purified by being heated and allowed to settle again, or by filtration, and is called summer yellow oil. Winter yellow oil is made from the above material by chilling it until it partially crystallizes, and separating the stearine formed, about 25 per cent., in presses similar to those used for lard. This cotton-oil stearine is used for making butterine and soap. The yellow oil obtained as above is treated with from two to three per cent. of fullers' earth in a tank furnished with apparatus for keeping the mixture in motion. When the fullers' earth has been thus thoroughly mixed with the oil, the whole is sent to the filter press. The fullers' earth has the property of absorbing or holding back the yellow colouring matter, so that the oil which issues from the press is almost white. The colouring matter, termed *gossypin*, is collected in a filter, carefully washed to remove any trace of acid, and dried slowly at a low temperature. It is then ready for use as a dye, and gives fast colours on both silk and wool. It is claimed that the quantity of colouring matter in a ton of crude oil is fifteen pounds, although this proportion must vary considerably. Its properties are insolubility in acids, slight solubility in water, free solubility in alcohol or alkalis. In its dry state it is a light powder of a pungent odour, of a brown colour, and strongly tinctorial.

PRODUCTION OF TURKISH WINES.

Her Majesty's Consul-General at Constantinople, in his last report, states that the wine industry has made considerable progress of late years in Turkey, and this is due in a great measure to the ravages caused by the phylloxera in France. Turkish wines have found great favour with French merchants on account of their body, deep colour, and alcoholic strength, which fit them for blending with French productions, these latter being, it appears, deficient in the above qualities. The districts from which the largest quantities are exported to France include Kiok Kilissé, in the province of Adrianople, and Miriofito and Daridja, in the Marmora. The latter place, which is on the northern shore of the Gulf of Ismidt, is unrivalled as a wine-growing district, in consequence of its excellent climate, fertile soil, and suitable aspect. These conditions attracted the notice of resident Europeans, who introduced the choicest French varieties of vine into the district about eighteen years ago with very successful results. The produce of these vineyards is now known as Erenkeuy wines, and the district in which they are grown is situated on the shores of the Gulf of Ismidt, opposite the Princes Islands, and facing the south, the land sloping gradually to the sea from a height of 200 to 300 feet. The soil is reddish-coloured, and contains iron and clay, as well as lime, of which the underlying rocks are mostly composed. The depth of the soil is three to four feet, and often more, and the fertility is such that the vines are often too vigorous and run to wood, instead of giving fruit, during the first five or six years of their growth. The best wines in this neighbourhood are made from grapes grown upon French vines imported eighteen years ago, and the cultivators are two Germans, three Englishmen, and two or three natives. The extent of the vineyards is not much over 100 acres, planted with 500,000 vines, and producing about 50,000 gallons in good years. The varieties of these French sorts are (1) Medoc (Cabernet, Sauvignon, Malbec, and Merlot); (2) Burgundy (Pinot, franc noirieu); (3) Hermitage (La Petite Syra); and (4) Beaujolais (Petit Gamais). All these descriptions produce wines richer in colour, body, and alcoholic strength than the vines in France, and it is said are like them in bouquet and keeping qualities. They contain 12 to 13 per cent. of absolute alcohol, and therefore require no addition of this or any other ingredient whatever. These wines are very highly appreciated wherever they have become known, and the cultivation would have been greatly extended but for the appearance, a few years back, of the phylloxera in some vineyards of native vines only a few miles off. The climate of this region is excellent, the mean temperature from the blossoming of the grape to the vintage being 21° Centigrade, and the rainfall in this period is seldom more than two to three inches. The Burgundy ripens first, about the 1st to the 5th of September; Beaujolais and Hermitage, 10th to 15th; and the Médoc, 20th to 25th; all generally before the first autumn rains. Hailstorms are not unknown, but are not frequent or very destructive. Frost seldom does any harm to the vine in Turkey. The quantity of ordinary native made wine exported in 1886-87 was 21,488,521 litres, valued at 31,151,916 piastres (at 112 piastres to the £), or at an average of 33 francs per hectolitre; and for 1887-88, 20,308,521 litres, of the value of 28,574,682 piastres, or an average of 31 francs per hectolitre. The whole of this wine has been exported to France, and the prices obtained prove its superiority over the foreign wines imported into that country. In conclusion, Consul-General Fawcett adds—"Turkish wines, although injuriously affected by primitive methods of cultivation and treatment, appear to be vastly superior to the ordinary wines of Southern

France, otherwise French merchants would not buy them at double the prices paid for French wines at Cette, Montpellier, and Perpignan. The fact is worthy of the attention of English merchants, inasmuch as the wine producers in France are agitating for the imposition of a heavy protective duty on Turkish wines, equally with those of Italy and Greece. This will have the effect of further reducing the quantity of French wines exported to England."

HAT AND CAP MAKING IN FRANCE.

The manufacture of hats and caps in France has for some years now been greatly extending, and it increases from day to day. At the commencement of the industry its progress was very slow, for in 1820 the value of the production hardly exceeded 25,000,000 francs, and this amount had only increased to 35,000,000 in 1849. Since that date, however, the progress made by this industry has been very rapid, and in 1872 the value of the production of hats and caps exceeded 50,000,000, while at the present day it amounts to 70,000,000 francs. The export of hats was not without a certain importance in 1888, and exceeded the exports of the preceding year by about a third. Indeed, the quantity of head coverings shipped in 1887 to foreign countries, Algeria and the Colonies, which did not exceed, in so far as regards felt hats, 1,143,738 in number, representing a value of 4,289,018 francs, increased in 1888 to 1,606,521, with a value of 6,024,554 francs. The exports of woollen hats have equally increased; they rose from 79,920 in number in 1887, to 131,581 in 1888. On the other hand, silk hats have considerably fallen off in the exports during the last three years. In 1886, 14,453 were shipped, while in 1888 the number had fallen to 6,122. The port of Marseilles has a share in the export trade, and this town a century ago was one of the most important centres of the hat industry, and shipped vast quantities of silk hats and caps to foreign countries and the Colonies. Marseilles has now ceased to be a large manufacturing centre of hats, and its place is taken by Aix, although there are still a certain number of factories in the former city which annually turn out a considerable quantity of hats and caps.

THE LIBRARY.

The following books have been added to the Library since the last announcement:—

Arts and Crafts Exhibition Society.—Catalogue of the First Exhibition, 1888 (London: 1888).

Beken, George.—The Rating of Ground-rents. (London: 1889.) Presented by the Author.

Bennett, W. B. G.—Southampton Sewage-clarification and House-refuse Disposal Works. (Southampton: 1888.) The New Sanitary Works of Southampton. (Southampton: 1889.) Presented by W. Whitaker, F.R.S.

Burrell, Edward J.—Elementary Building Construction and Drawing. (London: Longmans, Green and Co., 1887.) Presented by the Publishers.

Clode, Charles M.—The Early History of the Guild of Merchant Taylors, with Notices of the Lives of some Eminent Members. Part I.—History. (London: 1888.) Presented by the Author.

Emerson, P. H., B.A., M.B.—Naturalistic Photography for Students of the Art. (London: Sampson Low and Co., 1889.) Pictures from Life in Field and Fen. (London: George Bell and Sons, 1887.) Idylls of the Norfolk Broads. (London: Autotype Company.) Presented by the Author.

Farenc, Ernest.—The History of Australian Exploration from 1788 to 1888. (Sydney: Turner and Henderson, 1888) Presented by the Agent-General for Victoria.

Gupté, B. A. — The Industrial Arts of Poona. (Bombay: 1888.) Presented by the Author.

Haynes, W. H.—The Traces of Roman Occupastill existing in and about Dorchester. (London: 1888.) Presented by the Author.

Maiden, J. H.—The Useful Native Plants of Australia. (London: Trübner and Co., 1889.) Presented by the Author.

Matthews, William.—Southampton Waterworks, 1290-1889. (1889.) Presented by W. Whitaker, F.R.S.

Naylor, R. A.—Letters on Sweden and Norway. (Printed for private circulation.) Presented by the Author.

Queensland Illustrated Guide; for the use of Farmers, Fruit-growers, Vignerons, and others. (Brisbane: 1888.) Presented by the Department of Agriculture, Brisbane.

Shore, T. W.—The Proposed National School of Forestry considered as a Hampshire Commercial Question. (Southampton: 1888.) Presented by W. Whitaker, F.R.S.

Siemens, Sir C. William, F.R.S., D.C.L.—Scientific Works of, edited by E. F. Bamber. 3 vols. (London: John Murray, 1889) Presented by the Executor of the late Sir William Siemens.

Simmonds, P. L.—The Popular Beverages of Various Countries. (London: J. Gilbert Smith, 1888.) Presented by the Author.

Stone, T. W.—Notes on Water Supply in New Countries. (London: E. and F. N. Spon, 1888.) Presented by the Author.

Tallack, William. — Penological and Preventive Principles, with special reference to Europe and America. (London: Wertheimer, Lea and Co., 1889.) Presented by the Author.

Wardle, Thomas.—Silk: its Entomology, History, and Manufacture, as Exemplified at the Royal Jubilee Exhibition, Manchester, 1887. (London: Edward Bumpus.) Presented by the Author.

Whitaker, W., F.R.S.—Some Essex Well Sections. (From the Transactions of the Essex Field Club, 1886.) Hampshire Well Sections. (Extracted from papers and proceedings of the Hampshire Field Club, 1889.) Presented by the Author.

Journal of the Society of Arts.

No. 1,914. Vol. XXXVII.

FRIDAY, JULY 26, 1889.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

ART-WORKMANSHIP PRIZES.

The Society of Arts offer the sum of £150 in money prizes, as well as twenty of the Society's Bronze Medals, for objects in the Arts and Crafts Exhibition to be held in the autumn of the present year. The judges will be empowered to distribute the money, or such proportion of it as they see fit, in any sums they think will best meet the relative merits of the exhibits, at the same time paying due regard to the cost of production. The whole sum will only be expended in case of works of sufficient merit being forthcoming.

It will be understood that the Arts and Crafts Exhibition Society do not undertake responsibility in respect of the awards of the prizes, which will be a matter solely under the control of the Society of Arts.

The following rules under which the prizes will be offered are substantially the same as those under which the previous art-workmanship competitions of the Society have been carried out.

The prizes will be awarded to craftsmen, not professional artists, and the work must have been executed in the United Kingdom or its dependencies.

The objects submitted for competition may be the work of one workman, or of several workmen working in combination. They need not necessarily be the property of the workman or men sending them in. Manufacturers or employers may exhibit articles on behalf of their workmen. In this case, besides the name of the manufacturer, the names must be given of all the workmen who have executed portions of the work, with a statement of the portion executed by each. If any prizes are awarded they will be given to the workmen.

In awarding the prizes, the judges will take into account the following points:—

1. Originality or beauty of design.
2. Fitness of treatment.
3. Excellence of workmanship.

The works will remain the property of the competitor or of the person from whom he has borrowed them for the competition.

All the prizes are open to male and female competitors on equal terms.

The Exhibition of the Arts and Crafts Exhibition Society will open at the New Gallery, Regent-street, on Monday, October 7th, and will close on December 7th.

The following is the classification of the objects to be received for exhibition, as put forth by the Arts and Crafts Society:—

(a) Designs and cartoons for decoration of all kinds.

(b) Decorative painting—more particularly in association with architecture or cabinet work.

(c) Textiles—Tapestry, Needlework, woven and printed patterned Fabrics, Lace.

(d) Painted glass.

(e) Pottery—Tiles, Majolica, painted China.

(f) Table glass.

(g) Metal work—Wrought iron, brass and copper Repoussé, Gold and Silversmith's work and Chasing.

(h) Wood-carving } Carving in ivory and
(i) Stone-carving } other materials.

(j) Cabinet work—inlaid, and painted and carved furniture.

(k) Decorative Sculpture and Modelled Work—Friezes, architectural enrichments, relievos, plaster and gesso work, &c.

(l) Printing—Book decoration, Printers' ornaments, Illuminations and decorative MSS. Wood and metal engraving.

(m) Book-binding and cloth-cases.

(n) Wall papers.

(o) Stencilling.

(p) Leather work—Stamped, tooled, cuir-bouilli, &c.

And such other kinds of decorative Art not above enumerated as may be approved by the Selection Committee.

Information respecting the Exhibition and

forms of application may be obtained from Mr. Ernest Radford, Secretary of the Arts and Crafts Exhibition Society, at the office, 44, Great Marlborough-street, London, W.

H. TRUEMAN WOOD,
Secretary.

Proceedings of the Society.

CANTOR LECTURES.

HEAT ENGINES OTHER THAN STEAM.

BY H. GRAHAM HARRIS, M.Inst.C.E.

Lecture II.—Delivered May 13th, 1889.

SYLLABUS.

Boyle's Law—Gay Lussac's Law—Expansion—Indicator Diagrams—Watt Indicator—Original Instrument—Richards—Mode of testing Engines.—Balance-sheets—Division of Classes—Hot-Air Engines—Types of these—Use of Regenerator—Stirling—Bucket—Ericsson—Bailey—Rider—Other engines—Possible Efficiency—Actual Efficiency—Losses—Practical difficulties—Modes of overcoming these—Suggestions for Improvement.

When we left off on Monday last, we had commenced to discuss the question of expansion in a heat engine, and I had shown you how it was possible, by stopping the inflow of the working agent to the cylinder of the engine, at an early part of the stroke of the piston, to obtain an increased useful effect from the steam which was used.

We have now to consider this question of expansion in its application not only to steam, but to other gases, such as are commonly used in heat engines for power purposes.

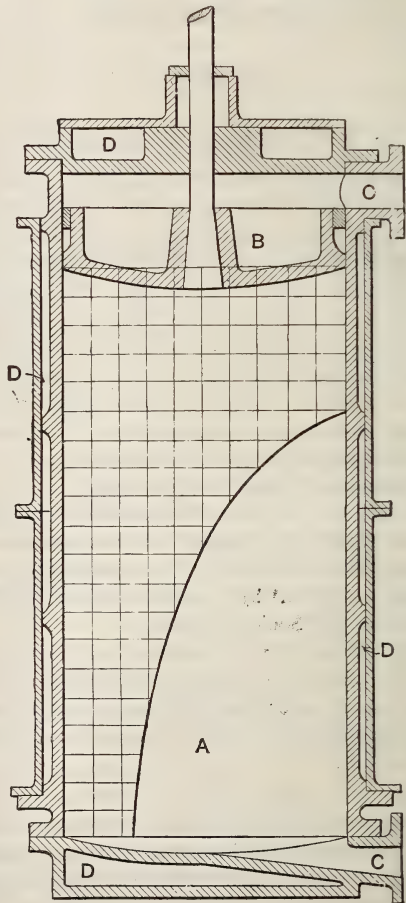
The diagrams which I showed you last week are the theoretical diagrams for the various points of cut-off which I then stated, these diagrams being calculated out according to one law governing the expansion of gases.

If you will remember, when dealing with the question of the specific heat of gases, I pointed out to you that this specific heat varied according as the pressure or as the volume was kept constant. Of the two laws governing the expansion of gases, the first—propounded in 1662 by Robert Boyle, and commonly known as Boyle's law, or sometimes as Marriott's law—may be briefly stated as follows:—

That the pressure of any given quantity of a gas varies inversely as its volume (in other words, as the space occupied), providing the temperature is kept constant; or put in another way, with any given quantity of a gas the product of the multiplication of volume and of pressure is always the same; for if volume is decreased pressure is increased, or *vice versâ*, always providing, as I have already said, the temperature is kept constant.

James Watt was one of the earliest who applied this law to demonstrate the expansion of steam, which may be called the "gas" of water. In the year 1782, Watt took

FIG. 10.—WATT'S DIAGRAM OF ENERGY.



out a patent, No. 1321, for "Certain new improvements upon steam or fire engines for raising water and other mechanical purposes." In this, Watt gave a diagram illustrating the economy to be derived from the use of expansion.

I will ask you to look at Fig. 10, which

is a copy of this, and is said to be the first published diagram of the energy developed by a gas in a heat engine.

This diagram is shown inside the steam cylinder, and not outside, as was the case with the diagrams we considered last week. You will see that the length of the stroke of the piston is divided by the horizontal lines or ordinates into twenty equal parts, so that the vertical lines represent movements of the piston, the horizontal lines, or ordinates to the expansion curve, representing, by their length from the side of the cylinder (which is the base line), the pressures existing at various portions of the stroke. At each of the ordinates there is printed (in the original drawing) the estimated pressures existing at these portions of the stroke, and Watt shows in his patent that, taking the initial pressure as unity, the sum of all these is 11·562, which, divided by 20—the number of the ordinates—gives, approximately, ·58 as the mean pressure of the steam during the whole stroke. As you will see, the steam is supposed to be cut off at a quarter of the stroke. Watt's statement of the advantages which are obtained is in these words:—

"Whereby it appears that only one-fourth of the steam necessary to fill the whole cylinder is employed, and that the effect produced is equal to more than half of the effect which would have been produced by one whole cylinder full of steam, if it had been permitted to enter freely above the piston during the whole length of its descent."

You will of course realise that if the steam were cut off earlier in the stroke, say at 1-8th, a greater per-centage of effect would be obtained from the same quantity of steam, tor the expansion curve would be carried on to a lower point. I have used this diagram to impress upon you that the value of expansion has been understood from the earliest days of the steam engine, and because it serves the purpose of illustrating Boyle's law—to which I have referred—propounded some 120 years before the date of Watt's patent.

I have already stated to you what this law is, and the diagram of Watt is the theoretical diagram for the degree of expansion, shown, and in it the pressures at the various ordinates are calculated according to Boyle's law.

Let me re-state this law to you in other words, giving you further illustrations. It is "that the pressure of any given quantity of gas varies in versely as its volume, the temperature being kept constant"—that is to say, if you compress a given quantity of gas, so that the space occupied by it is only equal to one-half that which it had occupied before compression, its pressure will be doubled; or if you expand a quantity of gas, so that the space occupied is doubled, then the pressure will be halved, always providing that the temperature is kept constant. Further, please remember that these laws which govern the expansion of gases, are similarly operative when a gas is compressed. A curve of expansion, such as that shown in Watt's diagram—calculated, as it is, according to Boyle's law—is called an "isothermal curve," the meaning of the word "isothermal" being "unvarying temperature."

But you will tell me I have already stated, when considering the big gun diagram, that if mechanical work is done by a gas in expanding, some of its heat is transformed into this work, and that, therefore, unless some means are provided for maintaining the temperature of the expanding steam constant, in Watt's engine, the curve of pressure could not possibly be one of "unvarying temperature," such as he has shown, but that curve of pressure must be lowered by the amount of heat representing the value of the work done.

If you will again look at the diagram, however, you will see that Watt had realised this, for his cylinder is surrounded by a steam jacket, into which the free steam from the boiler was admitted; by this means he proposed to keep up the heat of the expanding steam in the cylinder, heat being transmitted from the boiler steam in the steam jacket to that which was doing work in the cylinder. Thus, the true isothermal curve which he has shown was theoretically possible.

It is hardly our business to go into the question of the advantages of the steam jacket in a steam engine, but I think, from what I have already told you, and from what I am about to tell you, you will realise that it is an advantage, not because it directly increases the efficiency to be obtained from any given quantity of steam, but because it enables a given quantity of steam to do more work in a smaller apparatus, offering, therefore, less opportunity for loss by radiation, or by contact with the cylinder walls.

But the question of the lessening of the total quantity of heat in an expanding gas, due to its transformation into mechanical work, brings us to the second law governing the expansion of gases—the law propounded by Charles (and

practically at about the same time by Gay Lussac and also by Dalton), somewhere about the years 1801 to 1803.

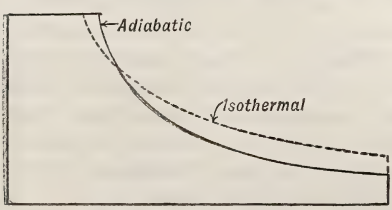
This law of Gay Lussac tells us that the pressure of a gas, occupying a given space, will vary directly as its absolute temperature; and it further tells us (and this is a mere corollary of the other statement) that the volume of a gas which can expand—that is, which is not restrained from expanding—will vary directly as its absolute temperature.

The diagrammatic curve of expansion, which assumes that in an expanding gas no heat can pass away from it through the sides of the vessel in which it is contained, and also that the total quantity of heat contained in the given quantity of gas shall only be lessened by the quantity turned into work due to its expansion, is called the "adiabatic" curve, the meaning of the word adiabatic being "not to pass through." Let me try to illustrate this to you.

Assume that we have a given volume of gas at a given pressure, contained in a vessel absolutely impervious to heat, but whose capacity we can increase at will, and assume that we allow this gas to expand, then, as according to our assumption none of its heat can be lost by radiation, or in any other way except by conversion into work, say in displacing the atmosphere, the curve of pressure will be the "adiabatic" curve.

It was necessary for our purpose that these laws should be stated, and the two curves should be shown, because when we come to consider the diagrams of energy obtained from various forms of heat engines (especially those where some of the work done by the expansion of the gas is absorbed by the subsequent compression of the gas, for the succeeding stroke, previous to its ignition) we must be, to some extent, familiar with these two forms of curves.

FIG. 11.—EXPANSION DIAGRAM.



Whilst we are upon this question, I will ask you to look at Diagram No. 11, where you will see by the dotted line, the isothermal curve, and by the full line, the adiabatic curve of expansion, and you will remember that, unless the heat is maintained, the adiabatic curve represents the one which would arise if the heat lost by the gas on expanding were all turned into work

To those of you who care to pursue this rather abstruse question farther, I would suggest a full consideration and study of the lectures, and the book based on these lectures, afterwards published by Mr. William Anderson, to which I have already referred.

But now, having spent all this time in dealing with the theoretical curves of expansion, I am going to tell you that, in a real heat engine, these theoretical curves are neither of them practically realised. The curves really obtained, although they may approximate to these, do so for reasons with which time will not allow me now to trouble you, and the curves obtained in practice vary, as we shall see, in accordance with the construction of the engine, with the nature of the working agent employed, and with the work really done by it.

Still, it was necessary that we should briefly consider these laws with the theoretical expressions of them in the diagrams, because when we come to compare the actual diagrams obtained from the various sorts of heat engine, we shall find that the rudimentary knowledge which our brief consideration of these laws has given us, will enable us more fully to estimate the value of the results which are achieved in practice.

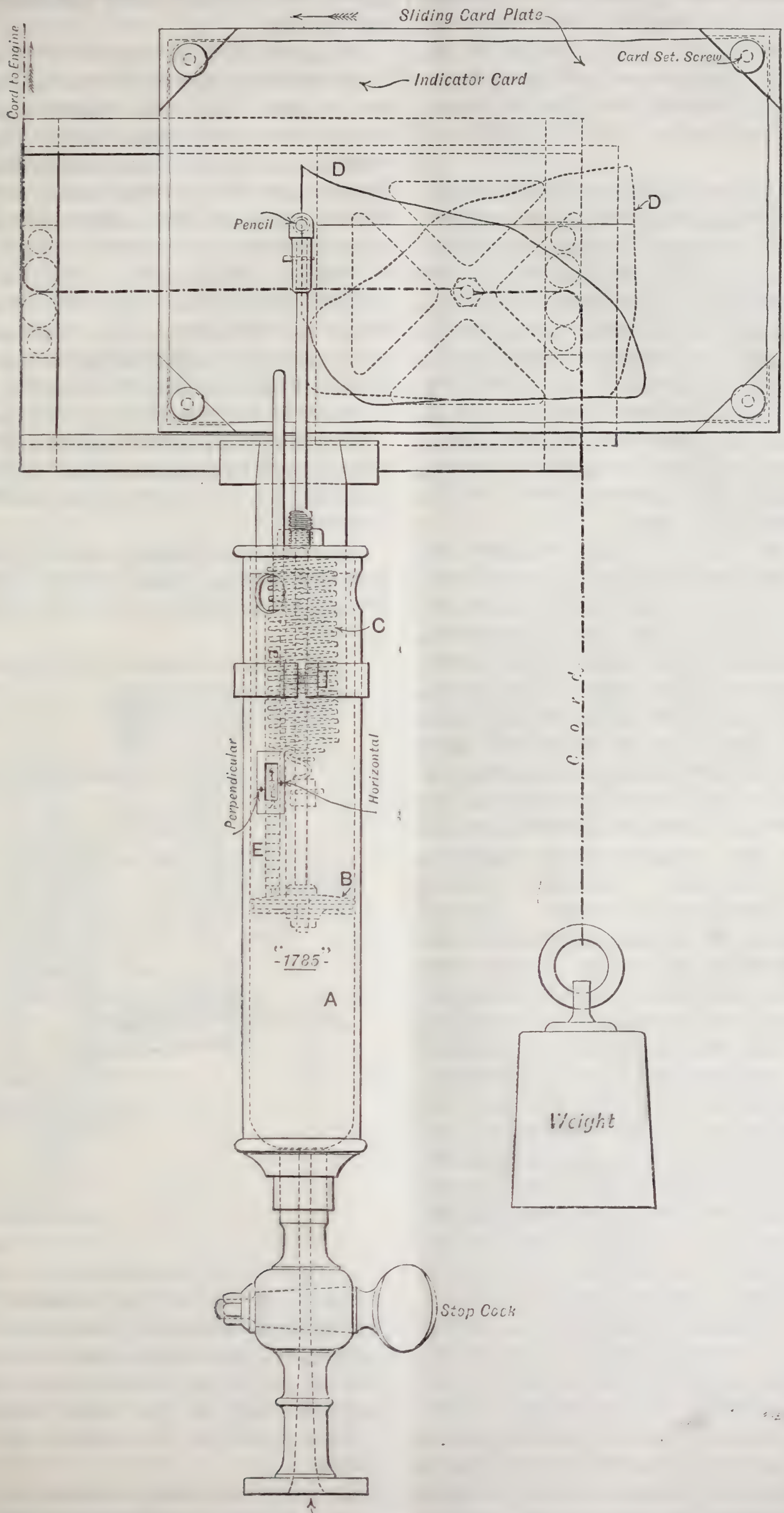
Now, the engineer, although he can construct by calculation the theoretical diagram, which should be obtained in any given engine, when he knows the initial pressure and the point in the stroke where the inflow of the working agent at full pressure ceases, yet he has had—from the very earliest days of the steam engine, and due to the genius of James Watt—an apparatus which he can attach to any engine, and which will enable him to tell that which is occurring in the cylinder.

Through the kindness of Mr. Wollaston Blake, of Messrs. James Watt and Co., the successors of the original firm of Boulton and Watt, I have here for you to see the actual instrument made and used 104 or 105 years ago (judging from the date upon it) by James Watt, and Fig. 12 (p. 715) gives you a diagram showing a section through the instrument.

Let me explain this apparatus to you. All of you can realise that if a pipe were connected to the space between one side of the piston and the cylinder cover of any engine,

FIG. 12.—WATT'S INDICATOR.

Taken from the original Instrument in the possession of Messrs. James Watt & Co., Soho Works, Birmingham.



end that if in that pipe there was another smaller cylinder, having a piston in it capable of movement, that smaller piston would be subjected, during the whole length of the stroke of the main piston—both away from, and back again towards, the cylinder cover—to the same pressure as existed in the main cylinder.

Now, if to the small piston you attach a rod, capable of moving as the piston moves, and if to that rod you fasten a pencil, so that it will make a record on a piece of paper, the small piston being normally kept in position by a spring, and only being moved when the pressure existing in the main cylinder comes upon it and against the resistance of the spring, the position to which the small piston moves at any portion of the stroke of the main piston will, if the strength of the spring is known, give us exactly the pressure existing in the main cylinder at any time.

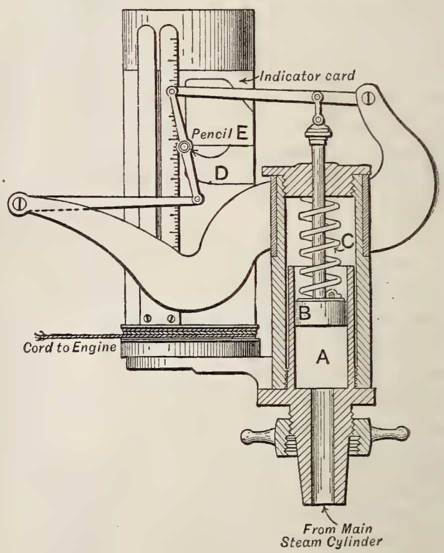
Now, if we cause the piece of paper on which the pencil makes its record to move backwards and forwards in accord with the movement of the main piston, and if we put the pencil in contact with the paper, we shall have a diagram produced, the length of which will bear a relation to the stroke of the main piston, and the height of which will show exactly the pressure existing at any portion of that stroke; in fact, it will tell us what the pressure is which exists at any moment in that end of the main cylinder of the engine to which it is attached. And this is exactly what the indicator does for us. You will see in Fig. 12 the sliding card plate moved in one direction by means of the cord which is attached to some reciprocating part of the engine, and moves with it, care being taken that the part to which it is attached makes its reciprocations in exact relation to those of the piston of the main cylinder. The reverse movement is made by means of the weight, which is lifted when the engine draws the card plate in one direction, and falling as the engine travels in the other direction, pulls the plate back with it. The lower portion of the indicator cylinder is attached by a pipe to the main cylinder, and in it there is a piston kept in its normal position by a spring. By means of the stop cock at the bottom the indicator cylinder can, at will, be put into communication with the main cylinder. The pencil is attached to the top of the piston rod of the piston of the indicator cylinder, and you see the sort of diagram which is made; the diagram giving, as I have said, an exact record of the pressure existing in the main cylinder at any part of the movement of the main piston.

The principle underlying the Watt indicator is the one which governs the various indicators now in use. The most important improvements which have been effected consist in making the piston of the small cylinder of a definite area for all indicators, in only allowing this piston to have a slight movement for a large variation in pressure, and in making the various moving portions of the apparatus as light as possible, so as to eliminate the evil effects of momentum. The small movement of the piston is multiplied by means of some kind of parallel motion to something largely in excess of the movement of the piston itself.

Here is one of the most commonly used forms of indicator—that known as the "Richards;" and here is a more recent form, known as the "Crosby."

You have a lithograph of the Richards indicator among those which have been handed to you (Fig. 13). In this the piston

FIG. 13.—RICHARDS'S INDICATOR.

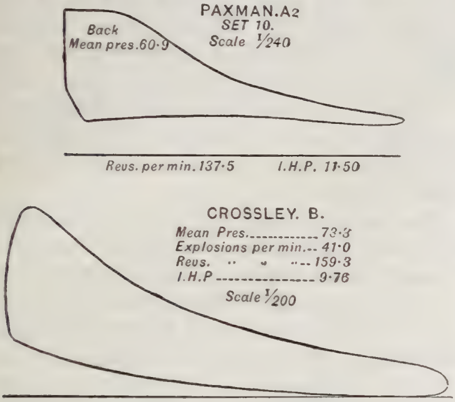


is marked B, the small cylinder A, the spring C, the pencil E, and the indicator card D. The principle upon which both these indicators work is, as I have said, absolutely similar to that of the Watt indicator, and they are improved only in the minor details — the "next-to-nothings" of working and manufacture.

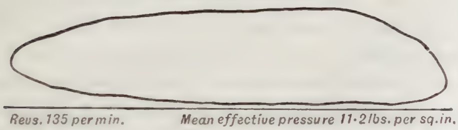
Having now shown you some of the theoretical diagrams and also the instruments

which produce the diagrams obtained in practice from real engines, let me ask you to look at some of these latter diagrams (see Fig. 14). In each case the horizontal line is

FIG. 14.—REAL INDICATOR DIAGRAMS.



RIDER HOT-AIR ENGINE.—DIAGRAM FROM POWER CYLINDER.



the line of atmospheric pressure, and the left-hand bottom corner of the diagram is the point of the commencement of the stroke of the main piston, which is supposed to be moving from left to right and back again.

You will see at the bottom a diagram obtained from the power cylinder of a hot-air engine, and you will see that in this the pressure rises, not very rapidly, at the commencement of the stroke which is to the left of the diagram, that it is slightly increased for a large portion of the stroke; and that it then falls, not with a hollow curve, but with a rounded curve, till the end of the stroke is reached; and you will see that neither the isothermal nor the adiabatic curve is even approached in such a diagram.

I shall have to deal very fully with similar diagrams to these three, when I come to consider the various engines from which they are obtained, and I will not, therefore, delay about them now. I will, however, just ask you to look at the indicator diagram from the steam engine which is at the top of Fig. 14, and the gas engine in the middle of Fig. 14, and you will see that, although the curves in these approximate to one of the theoretical curves, yet it is only an approximation.

The diagram obtained from petroleum engines is practically similar to these two.

In order to obtain motive power from any working agent, you will realise from that which I have told you, that it is necessary there should be a lessening of the heat existing in that working agent; that is to say, the temperature of the working agent at the time when it enters the engine, must, if work is to be obtained from it, be in excess of its temperature when it leaves the engine. From this we gather that in order to transform the heat in a working agent into mechanical work, it is a necessity that a series of changes or operations should be gone through; and it follows, if the transformation is to be continued, that this series of operations must be repeated.

In the steam engine, if it is double-acting, such a series of operations is usually completed in each revolution of the engine for each end of the cylinder; that is to say once for each end, or in one "in" and one "out" stroke of the piston. The engine at the commencement of one stroke, say the "out" stroke, receives the steam; the piston moves forward; the steam is cut off, and, the piston still moving forward, the steam expands; the piston getting towards the end of its stroke, the exhaust valve, or port, is opened (connecting with the condenser, if it is a condensing engine); the piston completes the stroke, then moves backwards till the "in" stroke is complete, and steam is again admitted.

This succession of operations is called a "cycle." We shall see that the cycles of different forms of heat engines vary considerably. In all indicator diagrams the "cycle" is represented by the continuous line enclosing a space, whose height, as I have said, at any point represents the pressure existing at that part of the length of the stroke.

As I shall have to compare the relative performances of some of the various kinds of heat engines used for power purposes, it will be as well that I should give some description of the mode which is adopted in making tests of these performances. For a thoroughly complete and detailed account of such a series of tests, it seems to me that I cannot do better than refer you to the report of the judges on the electric motor trials, published in the *Journal* of the Society for the week ending the 15th February last (No. 1,891).

I will not trouble you with the description of the mode adopted in making a complete test of a steam engine (this mode being practically

based on that used by Sir Frederick Bramwell and Mr. Anderson at the trials of engines made for the Royal Agricultural Society at their Cardiff meeting many years ago), but will ask you to examine the trials of gas engines, as being more germane to that which we have to consider. Trials of such engines as these, to be satisfactory, must give an absolute record of the quantity of gas consumed in the engine itself, and, in the case of those engines using gas for the ignition of the explosive mixture, this should also be measured, and, if possible, separately. Samples of the gas should be taken at frequent intervals during the trial, which samples should be afterwards analysed, so that the calorific value may be accurately ascertained. The pressure and temperature at which the gas is supplied to the engine must be measured; indicator diagrams should be taken at frequent intervals throughout the "run;" the power given forth by the engines should be absorbed by some reliable brake, the load which this puts upon the engine, or, in other words, the resistance which this opposes to the motion of the engine, being accurately ascertained; the temperature and quantity of the cooling water must be measured, not only as this water flows to the motor cylinder, but also as it leaves it; the number of revolutions of the engine throughout the whole run should be recorded, and the average number per minute, at frequent intervals during the run, must be taken as a check; the run must occupy a sufficient length of time to eliminate any errors arising from heating up the mass of metal of the engine; and, lastly, every instrument used throughout the trial should have readings taken from them at very frequent intervals, and these instruments should all be calibrated and tested for accuracy, both before the trials are made and after they are concluded.

Further than this, a trial of sufficiently long duration should be made with the engine running with its utmost load on, *i.e.*, exerting the utmost power which it is capable of exerting; another trial should be made with the engine running at about half-power; and a third with the engine running "light;" the above records being taken for each trial, and the results of each used to verify or check those obtained in the other trials. The exact diameter of the cylinder and stroke of the piston should be obtained, and any peculiarities in the construction of the engine or in its working during any one of the runs should be recorded. Experiments should also be made to determine the value of the control of the governor when the work is suddenly taken off the engine.

Having run your trials, and obtained all the information here suggested, and anything else which you can possibly think will be of the slightest value, the question arises how to state, so as to be readily comprehended, that which has been learnt, or in other words, how to "boil down" the mass of information thus obtained, so as to make the performance of the engine readily comparable with that of other engines.

The commonly accepted way of doing this now-a-days is by showing the results of the performance of the engine on a balance-sheet (see p. 719); *i.e.*, you debit the engine with so many units of heat delivered to it (these units being contained in the quantity of coal used to stoke the boiler furnace, or in the number of cubic feet of gas which your gas meter tells you has been supplied to the engine during the trial), and you credit the engine with the number of units which have been turned into work, with the number of units passing away in the exhaust, with the number of units passing away in the jacket water in a gas or petroleum engine, and with any other loss which there may be; and by this means you are able to tell exactly, and at a glance, what proportion of the total heat units delivered to the engine has been effectually utilised by it, and what proportion of the total heat units is represented by each particular head of loss.

In the motor trials for the gas engines, the judges adopted the plan of calculating for each explosion, or for each working stroke of the engine, its proportion of the total heat units, and they turned these into their value in foot-pounds of work, and then compared these with the foot-pounds per explosion, represented by the indicator diagrams; those represented by the heat rejected in the jacket water, and those represented by the heat passing away in the exhaust; coupled with the slight amount due to other losses, these three principal heads of use and loss represent the total heat units per revolution supplied to the engine.

Turning these into per-centages, it will be found that in the Atkinson gas engine (of which we shall have to speak later on) the heat turned into work, as shown by the indicator diagrams, was 22·8 per cent; the heat rejected in the jacket water was 27 per cent.; and the heat rejected in the exhaust, lost by imperfect combustion, and otherwise un-

Balance-sheet of Messrs. Davey Paxman and Co.'s Simple Engine.

Dr.	Units.	Cr.	Units.	Percentage
To the heat developed in furnace :—		By heat expended :—		
In the combustion of wood :—		1. In evaporating the water in the wood and heating its steam to 385°	9,557	·32
From Carbon	79,331	2. In heating the wood and the air required for its combustion from 70° to 385°	3,884	·13
,, Hydrogen	4,816	3. In evaporating the water in the coal and heating its steam to 385°	8,374	·29
In the combustion of coal :—		4. In heating the coal and the air required for its combustion from 70° to 385°	129,321	4·44
From Carbon	2,481,400	5. In displacing the atmosphere by the products of combustion of the wood and the coal with the air needed for their combustion	53,394	1·83
,, Hydrogen	337,475	6. In heating the excess of air	130,980	6·34
,, Sulphur	9,071	In displacing the atmosphere by the excess of air	53,509	
		7. In evaporating the water in the boiler	2,090,300	71·78
		8. In radiation and convection	271,307	9·32
		9. In ashes and unconsumed fuel	53,915	1·85
		10. Unaccounted for	107,552	3·70
	2,912,093		2,912,093	100·00

accounted for, made up the balance of 50·2 per cent.

In the Crossley engine, the heat turned into work was also 22 per cent., and in the Griffin engine was practically as much—that is to say, is represented by the red cube which we used last week.

I think I have now sufficiently explained the theoretical portions of our subject, and that we may devote the rest of our time to investigating the practical results which have been obtained.

(To be continued.)

Miscellaneous.

RICE CULTIVATION IN MALACCA.

The method of cultivating rice by the natives of the peninsula of Malacca, chiefly by Malays, and in part by Chinese, no Europeans being engaged in rice planting, is, says the American Consul at Singapore, as follows:—About the month of June, patches of good, moist land are selected, and prepared to serve as nurseries for seedlings to transplant. The ground is well and carefully hoed, and (as an average per farmer) about three-fourths of a picul (picul = $133\frac{1}{3}$ lbs. avoirdupois) of good paddy is strewn broadcast on the seed beds. After germination, and the growth of the plants to seven or eight inches high, water to a depth of three or four inches is let in on the land. When the plants are about twelve inches high, more water, to a depth of six or seven inches, is let in, and kept in that state. Then the land or rice-field to receive the seedlings is ploughed and banked up in partitions, or patches, of four to six to an acre. When ready, and rain has fairly set in, about the middle of August (beginning of the monsoon change), the seedlings are transplanted into the prepared land. Women, as a rule, do this work. They take a bundle of seedlings tied in front, and a pointed stick, and make a hole in the land about four inches deep, and in this they set from six to eight seedlings. Before transplanting, the roots of the seedlings are dipped in a solution of powdered bone manure until all are planted. All now depends upon the weather; if there is not too much rain, or drought, or tempestuous weather, the crop will be good, and yield, on an average, per acre about 800 gantangs of paddy (at 20 gantangs per picul, this would give 40 piculs = $5,333\frac{1}{3}$ lbs. avoirdupois). In January and February the crop is ripe, and harvested with small cycles. The whole process of cultivation, harvesting, drying, threshing, and hulling the paddy to make rice is most primitive and slow. In harvesting, some farmers cut the straw near the ground, and others cut it from eighteen inches to

three feet below the ears. In harvesting, if the weather is fine, the grain is dried on rude platforms made of sticks, near the field, and then threshed. If the weather is bad, it is hung up to dry in sheds, open at the top, or covered with grass; in the case of small farmers it is hung up under the projecting roof of the huts they live in. The grain being dry enough for threshing, those who have no cattle to tread it out beat the paddy from the straw with a small club, while holding a sheaf or handful over the edge of a block or large, strong box, and pull off with their hands what escapes the club. To prepare the rice for daily consumption, the farmers beat or pound it in small heaps, with a club, until the hulls become well loosened, and they then rub it between their hands until the rice kernels drop out. The people, when they have a surplus of their crops to sell, as a rule sell not rice, but paddy. As to the cost of cultivating an acre of paddy till it is harvested and secured, depends very much on the locality, circumstances, and condition in and under which the farmers live and labour. Consul Studer says that he has consulted various authorities; some claim that in a fair year they can harvest from 50 to 55 piculs of paddy, in other parts of the country from 40 to 45 piculs, and in others 36 piculs only. Some estimate the cost of planting and securing the grain as high as £10 down to £5 per acre. About £6 is considered to be a good average. Consul Studer is of opinion that, if properly fostered and encouraged, the territory embraced within his consular district, instead of being a rice-importing country, could in a few years be made a self-sustaining one at least—that is, if energetic planters would take the matter in hand. An alteration would, however, have to be made in the implements used in cultivation. For example, the following is a description of the field plough used:—The native takes a medium-sized sapling, and fastens at the thicker end two bent sticks to answer as plough handles. About the middle of the sapling he bores a hole to hold the ploughshare, sometimes made of iron, but in the remote jungle districts of very hard wood, many species of which abound in the forests. This implement is simply a very stout bar, which below the beam fastening takes a gradual inward curve forward, and at and near its end it broadens, and there are two arrow or anchor-shaped flukes that give it the appearance of a small pointed shovel. To this implement the native fastens his bullocks—or, what is more frequent, one of the indigenous buffaloes—with an iron ring or rattan, through his nose, to either side of which is fastened a small rope to answer as a rein, and this gives the farmer complete control over his beast. The farmer manages to stir up and loosen the mud with this instrument, and this is what in the main is needed, the paddy land being marshy, or low river-bottom, and therefore soft to plough. Upland, or hull paddy is also planted in places generally near the base of a hill on gently-sloping land. In this case the plough is not used, but the land is hoed as finely and deeply as possible, and land above it, lying higher, is so arranged by little ditches as to give the rice fields below all off-flowing rain water. Hull paddy, while it produces good well-flavoured rice, gives a smaller, less plump grain than swamp paddy, and, as a rule, it is consumed by the natives planting it, and not sent to market.

THE SILK INDUSTRY OF DAMASCUS.

The silk industry of Damascus, which was formerly in a very flourishing condition, has for some years past fallen off to a very considerable extent. The number of looms, which ten years ago amounted to 3,000, employing 20,000 workpeople, now do not exceed 1,700, and the number of workpeople employed has fallen to 10,000. This marked decadence is attributable, says the *Journal de la Chambre de Commerce de Constantinople*, to European competition and the wretched condition of the peasants. The stuffs manufactured from the raw material, brought for the most part from abroad, and worked up by hand in a rough and clumsy manner, cannot compete with European products manufactured in factories supplied with machinery of the most perfect types. From ten to fifteen years ago the quantity of silk used for weaving amounted to about 102,400 kilogrammes, while at the present day only about half this quantity is consumed, the greater part being imported from Shanghai and Persia. Lebanon only supplies a small quantity of silk of a superior quality. The principal articles of which the actual production is composed are of three descriptions—the *cotni*, *aladja*, and *dima*. *Cotni* is a stuff with woof of silk and warp of cotton, and stripes of all shades; this is used for clothing, and more often for upholstery. The annual production is about 110,000 pieces, valued at from fifteen to twenty-six francs the piece of six metres in length by seventy centimetres in width, and at from five to ten francs the piece of one metre and a half long by seventy centimetres wide, the whole forming a total value of about 2,000,000 francs. The *aladja* is a tissue with silk woof and cotton warp with varied stripes, generally watered, and is used chiefly for articles of wearing apparel. The annual production is about 192,000 pieces, the total value of which is estimated at 1,400,000 francs. The *dima* is a tissue with silk woof and cotton warp, stripes of all shades—used for upholstering and wearing apparel. The annual production is about 350,000 pieces, valued at 1,000,000 francs. The value of the production of the three categories is therefore 4,400,000 francs. Of this production the City of Damascus only consumes about 3 per cent. of *cotni*, 6 per cent. of *aladja*, and 15 per cent. of *dima*, representing a value of from 400,000 to 500,000 francs. The remainder is exported, the greater part of the *cotni* going to Constantinople, Anatolia, and Bagdad, the *aladja*

chiefly to Anatolia, and the *dima* to Constantinople and Anatolia. The foregoing represent the three principal descriptions of Syrian manufacture. The articles next in importance are the *mabroums*, *abas*, *kefiehs*, and shawls. By *mabroum* is designated a light cotton tissue with loose woof, which is used for wearing apparel. The production of this article was formerly of very great importance, amounting to nearly 300,000 pieces annually. Damascus has now been supplanted by Homs, Hama, and particularly by Broussa. It is from these three towns that Damascus is supplied with *mabroums*, the latter place only manufacturing a very inferior article. The *aba*, or *machia*, is the cloak of the inhabitants of the district. The finer description of *aba* is woven with silk and gold threads, but the coarser kinds are made of wool. The latter are generally used by the peasants and villagers. Notwithstanding the large consumption of these articles, they are still classed as secondary products of Damascus, as the markets of that city is chiefly supplied by the factories of Homs, Hama, and Bagdad. The *kefieh* is a large handkerchief with fringes, which is used as a covering for the head or the shoulders. It is made either entirely of silk, or of silk mixed with cotton. Its dimensions vary between 75 centimetres and 1 metre square. The finer descriptions of *kefieh* are manufactured only in small quantities, and exported. Homs, Hama, and Bagdad have, in a great measure, taken away from Damascus the manufacture of the cotton *kefieh*. The shawls which are manufactured are in imitation of those of Cashmere, the designs of which are generally faithfully reproduced. They are made of cotton, or with the woof of cotton and the warp, mixed with silk and cotton. Those entirely of cotton are generally worn by the peasants, while the others are used by persons in a better position in life. They are also used as waist bands. They usually measure 2 metres in length, and 1 metre in width. In concluding the list of stuffs woven at Damascus, the following should be mentioned — curtains, trimmings, sofa covers, pocket handkerchiefs, and ladies' veils of cotton and silk.

THE PLUM TRADE IN BOSNIA.

A report on the plum crop of Bosnia for 1887 and 1888 has recently been published, from which some idea of the importance of this branch of industry may be gathered. It is, as described, the most important product of Bosnia, and forms the chief article of export from the province. The poorest peasant has a few plum trees by his hovel; wealthy landowners never think of planting any other kind of tree by their country houses; and on the result of the plum crop, more than any other, depends the well being of the agricultural population. It is not possible to make even an approximate estimate of the whole province, as no statistics on the subject are collected by the Government. In a good season, 39,368 tons of the dried fruit are exported, representing a sum of more than £200,000 sterling. Add to this the large amount consumed in the distillation of the spirit commonly drunk in the country, called "slivovitz;" and to make an ordinary kind of jam, prepared without sugar, called "bestilj," much eaten by the natives, and some idea can be formed of the immense value of this crop to the province.

The dried fruit is almost exclusively exported from the Possavina and the northern districts of Bosnia. Exportation from the interior is insignificant, the cost of transport being too heavy; nor is the fruit, apparently, of so fine a quality. The crop of 1887 was, perhaps, the best on record, as regards both quality and quantity.

The plums, after gathering, are dried in ovens, and then separated into six qualities, determined by the number of fruit required to make half a kilogram. This is effected by passing them through sieves of different sizes. The first quality must not have more than 75 plums to the half kilogram, the second 80, the third 85, the fourth 90, the fifth 100, and the sixth 110 to 115. The first quality is packed in rough boxes containing 5 to 10 kilograms; the other qualities in sacks or barrels. As is usually the case when there is an abundant crop, there was in 1887 a deficiency of sacks and barrels in readiness. These had to be procured in haste from a distance, at a cost considerably above their value, involving no inconsiderable loss to the traders. The export trade is chiefly in the hands of German houses at Berlin, Ratisbon, Monaco, &c. There was formerly a considerable trade with this article with America, but it appears to have fallen off of late years; nearly the whole of the crop of 1887 went to Germany and Austria-Hungary.

During the past few years there has been a steady increase in the exportation of dried plums from Bosnia, making allowance naturally for the fluctuations of the crop. A still further increase may be confidently looked for, as the producers, finding that the article always commands a ready sale, are beginning to take more trouble in the cultivation and drying of the fruit.

No inconsiderable portion of the crop of 1887 is said to have been lost owing to the primitive way in which the fruit is dried, which involves a great loss of time.

The plums must be gathered only at a certain stage of ripeness, and when the crop is abundant the peasants are not able to dry them sufficiently fast, and immense quantities therefore rot and are lost, or at best can be made only into inferior "slivovitz."

The local Government has turned its attention to this matter, and in many parts of the plum-producing districts has established drying-ovens of improved construction, which have been very successful, and effected a great saving of time and labour. Some few landed proprietors have followed

the example set by the Government, and constructed similar ovens on their estates, but the peasants in general are slow to learn, and averse to all innovations, and it will probably be some years before these improved ovens come generally into use.

The plum crop of 1888, which promised at one time to be equal, if not superior, to that of 1887, was much affected by the unusually dry summer. The fruit was small, and much of it fell from the trees while still green. In spite of this, however, it was a fair average crop, but the quality was inferior, and the prices consequently low.

GERMAN RAILWAYS IN 1888.

The total length of the German railway lines on the 1st April, 1888, amounted to 39,157 kilometres (kilometre = ·621 of a mile), of which 27,921 kilometres, or 71·3 per cent., were single lines; 11,174 kilometres, or 28·5 per cent., double lines; and 62 kilometres treble lines. The various State systems (Prussian, Bavarian, Saxon, Wurtemburg, &c.) figured in the total length for 34,394 kilometres, or nearly 88 per cent.; railways worked by private companes only represent a length of 4,763 kilometres. In the course of the year 1887-88 the repurchased railways—from Berlin to Dresden, Nordhausen to Erfurt and Aix-la-Chapelle — were incorporated in the Prussian system, of which the length amounted to 22,690 kilometres, or 944 kilometres more than in the year 1886-87. Compared with the population, Germany counts on an average 22 kilometres of railways to every 10,000 inhabitants. The rolling stock comprised 12,811 locomotives, of which 2,680 were with tenders; 23,703 passenger carriages, with accommodation for 1,016,377 passengers; and 254,385 luggage vans and goods trucks, having a loading capacity of about 2,500,000 tons. In the year 1887-88, 316,000,000 passengers were carried over the German lines; 87 per cent. were third and fourth-class passengers, 10·4 per cent. second-class, and only 2 per cent. first-class. The total increase over the preceding year amounted to 20,000,000 passengers. The movement of merchandise is represented by 179,000,000 tons, carried over a total distance of 18,649,000,000 kilometres. The receipts were as follows in £. sterling—from passengers £14,694,840, from goods £37,536,640, and miscellaneous receipts £2,249,600, making a total of £54,481,080. If the expenses, amounting to £28,705,320, be deducted from this total, it leaves a balance of net revenue of £25,775,760.

NAPHTHA RESIDUUM AS FUEL IN RUSSIA.

Her Majesty's Consul at St. Petersburg says that naphtha residuum is being more and more employed as fuel in Russia. All the steamers of the Caspian, and many of those plying on the Volga, have for some time past used it as fuel. At the present time manufactories and railways are adopting it in the place of wood and coals. It is also being utilised for domestic purposes in stoves of special construction, ingenious specimens of which were exhibited last year at the St. Petersburg Naphtha Products Exhibition. By the employment of this new combustible a considerable saving is effected under the head of fuel. Some large manufactories in Moscow and its immediate neighbourhood employ naphtha residue in their furnaces, because in addition to its great cheapness, it possesses the advantage of occupying less space than wood or coal for storage. It is kept underground in large cisterns, communicating by pipes with the furnaces, and owing to this method of storage it is also less exposed to danger from fire. It is established that the cost of naphtha dregs as fuel is about 35 per cent. less than that of wood and coal, and this, too, at Moscow, which is 1,500 miles distant from the source of supply at Baku, whence naphtha dregs are conveyed by water to Nijni Novgorod, and beyond by rail to Moscow. Several manufacturers of the province of Vladimir have also adopted the new combustible, and the railway lines existing in the Tambov and Riazan provinces are on the point of doing the same. During 1888, 54,000,000 pouds (867,857 tons) of naphtha residue were transported from Baku up the Volga, for use in the interior provinces and in those bordering the Volga. It is expected that in 1889 the supply will exceed 70,000,000 pouds (1,125,000 tons). In the northern zone of the empire wood will, it is stated, hold its own as fuel for some time to come. It is specially central, south-eastern, and eastern provinces of Russia that the employment of naphtha residuum as a substitute both for wood and coal promises to attain great proportions.

General Notes.

VIENNA AGRICULTURAL EXHIBITION. — It is officially announced that a general national Exhibition of Agriculture and Sylviculture will be held at Vienna, next year, from the 15th of May to the 15th of October. The exhibition is to include the following international sections:—(1.) Machinery and implements used in agriculture, sylviculture, and the industries cognate to them, such as horticulture, viticulture, hop-growing, bees, silk, fishing, and hunting. (2.) Artificial and auxiliary branches of agriculture, such as artificial manures, remedies for sick animals, &c. (3.) Models, plans, designs, and statistical information respecting agriculture and forestry. (4.) Inventions dealing with the utilisation of waste material. (5.) Information and suggestions respecting the food supply of large cities.

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FRIDAY, AUGUST 2, 1889.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

ART-WORKMANSHIP PRIZES.

The Society of Arts offer the sum of £150 in money prizes, as well as twenty of the Society's Bronze Medals, for objects in the Arts and Crafts Exhibition to be held in the autumn of the present year. The judges will be empowered to distribute the money, or such proportion of it as they see fit, in any sums they think will best meet the relative merits of the exhibits, at the same time paying due regard to the cost of production. The whole sum will only be expended in case of works of sufficient merit being forthcoming.

It will be understood that the Arts and Crafts Exhibition Society do not undertake responsibility in respect of the awards of the prizes, which will be a matter solely under the control of the Society of Arts.

For further particulars see *Journal* (No. 1,914) for July 26th.

Proceedings of the Society.

CANTOR LECTURES.

HEAT ENGINES OTHER THAN STEAM.

By H. Graham Harris, M.Inst.C.E.

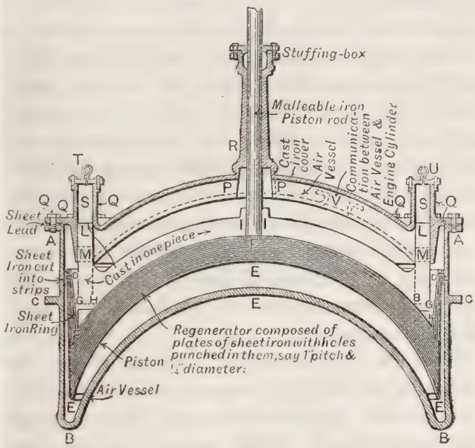
Lecture II.—Delivered May 13th, 1889.

(Continued from p. 719.)

I have for a long time been considering whether it was not possible to divide the various sorts of "heat engines other than steam" into some two or more great classes, having distinct and well-defined characteristics, but I have found it impossible; and although it is not scientifically correct to speak of hot-air engines, of gas engines, and of petroleum engines, as is popularly done—because, as a fact, these are all hot-air engines, yet, on the whole, I think it is better in our case to follow the popular division, even though it is scientifically incorrect. I propose, therefore, first to consider "Hot-Air Engines," then "Gas Engines," and then "Petroleum and other forms of Heat Engine," always using these titles in their popular sense.

One of the earliest successful hot-air engines was that invented and patented by the Rev. J. R. Stirling and his brother, in the year 1827 (see Fig. 15).

Fig. 15.—Stirling's Hot-air Engine, Patent of 1827.



We have already considered what is the effect produced by increasing the temperature of an enclosed volume of a gas such as air, the volume remaining constant; and I have also shown you the effect of increase of temperature on a volume of air—the pressure remaining constant, but the air expanding as heat was applied; and you will have realised that an ideal heat engine for power purposes would give the greatest efficiency if (among other advantages of which we shall have hereafter to speak) all increases of temperature in the working agent were made with its volume remaining constant (or even, it may be, being lessened), and all decreases of temperature were due to the transformation of heat into work during expansion.

But to construct a hot-air engine such as this, in which a reasonable power might be

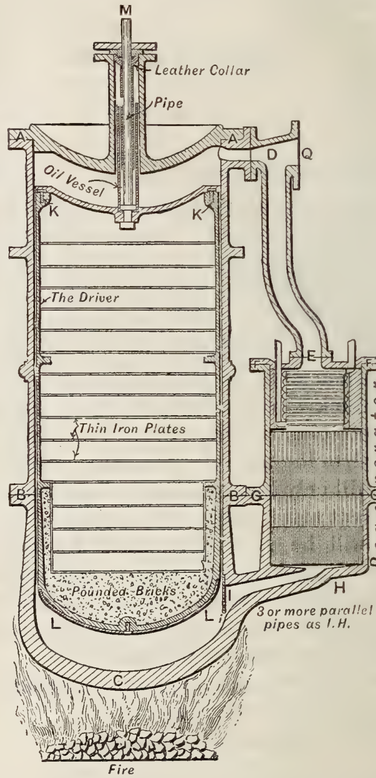
developed, would require, among other things, enormous cylinders ; for the pressure at which the engine would work would practically be extremely low, and the element of time would become of great importance, *i.e.*, the time necessary to impart the large quantity of heat to the air, and to cool it, at each stroke would be considerable, with the result that the speed of the engine would be low. There is a device called a "regenerator," included in the first patent of Stirling (see Fig. 15), which to some extent meets this difficulty, and which, in other forms, is one of the most important devices in the arts and manufactures.

Let me try to illustrate to you what the principle of the regenerator is, and let me try first to define, pithily, the sense in which the word is here used. A regenerator is really a heat "filter," that is to say, the heat is filtered out of the hot air or of any hot gas passing through it. The apparatus consists of a series of absorbing surfaces — usually in hot-air engines there is a metal box filled with numerous thin plates, in contact with which the hot air or hot gases are caused to pass, and in doing so they give up the heat they contain to these plates or surfaces, and the hot air or hot gas leaves the further side of the regenerator at a temperature much lower than that which it had on entering it, because it has given up to the surfaces presented to it a portion of the heat which it contains.

Now, if the current of air or of gas be reversed (or if cool air or gas be allowed to pass in the opposite direction, back through the regenerator), it will re-pick up the heat which had been left behind on the first journey, and will leave the regenerator at almost as high a temperature as that which the hot gas had on first entering it.

The diagram, No. 16, shows a portion of the improved Stirling engine, which was patented in 1840. You will see the air vessel or cylinder marked C, in which a displacer or driver is contained, this displacer being capable of movement up and down in the cylinder. From the top of the displacer a rod, M, proceeds, working air-tight through a stuffing-box on the top of the cylinder. At the right hand side of the cylinder, at the bottom, you will see the pipe or passage, I, H, leading into the bottom of the regenerator box, G, and from the top of the regenerator box another pipe or passage, E, leading back into the cylinder above the piston. The regenerator, G, consisted in this case of a box filled with plates of sheet iron for two-thirds of its height, the remaining portion at the top being filled with small copper pipes, say 1-8th inch internal diameter, through which cold water was caused to circulate, the pipes forming a "cooler," in which any of the heat still left in the air was removed as it passed to and fro through the regenerator. A fire is kept burning under the bottom of the cylinder, C.

FIG. 16.—STIRLING'S HOT-AIR ENGINE, PATENT OF 1840.



Air was supplied to this cylinder or air vessel at a pressure of about 150 lbs. on the square inch by means of a small pump attached to the engine, which was worked from this cylinder, the pump serving also to make up any loss of air by leakage, or otherwise. There were two of these cylinders, each with its own piston or displacer, and with its own regenerator. One was attached to one end of the working cylinder of the engine, and the other to the other end of this cylinder.

Stirling's engine would work in the following way:—If one of the displacers was raised

it displaced the air above it, between its top and the cylinder cover, sending the air through the regenerator into the space below the displacer, where it would be subjected to the heat of the fire. Thereupon, the air, becoming hot, its pressure would rise, and this air of in-increased pressure would pass along through the passage, Q, which connects with, say, the top side of the piston of the working cylinder, and would thereupon force this piston down. The second air-vessel, which is similar to the one shown, having also a displacer and regenerator, is in connection with the other side of the piston in the working cylinder, and this piston in passing down would transfer the air contained in that end of the working cylinder into the space above the displacer in this second air vessel. Now if this diplacer is moved upwards the air contained in the space above it will be delivered through the pipe, E, through its regenerator, and will be heated in the space, L L, over the fire in the second air vessel. The pressure of this air will thereupon rise; will be communicated to the lower side of the piston in the working cylinder, and will cause that piston to rise, thus completing one "cycle" or series of operations, and bringing the engine back to the position in which it was when we commenced our description.

In order to start such an engine into motion the fires were lit under the air-vessels, and when all was thoroughly hot the displacers were alternately moved up and down by hand. You will see, as we go on, that one of the practical difficulties in connection with almost all heat engines other than steam is involved in this question of starting.

Let me point out to you what are the peculiarities of Stirling's engine. First, the air, by the alternate heating and cooling of which it is worked, has, as I have said, an initial pressure imparted to it of 150 lbs. on the square inch, and at this pressure it is maintained, as against loss by leakage or otherwise, by means of the small air pump.

You will realise, from that which I have told you as to the laws governing the expansion of gases, that a high initial pressure of the air is of great advantage from the point of view of economy of fuel consumption in a hot-air engine, because it would require a very much less quantity of heat in proportion to raise the pressure of the air by any given amount, than would be required if only used initially at the pressure of the atmosphere. As we have learnt, with a given volume or quantity of a gas, the same number of units of heat are required to double the pressure, no matter what that pressure may be. Another peculiarity of this engine is, that the same air is used over and over again; it is not exhausted from the engine at each stroke.

Let us now examine another hot-air engine, one of even earlier date than that of Stirling's first patent of 1827. I have shown this in Fig. 15, and you will understand it from the description I have given of the other engine. It is certain that no record of the history of hot-air engines would be complete without mention of the name of John Ericsson, who died in America (the country of his adoption) as recently as March the 8th last. He was an engineering genius. To him the invention of the screw propeller is sometimes attributed; he is credited with designing and building the first real ironclad, completing it in 100 days from the laying of the keel-plate. A steamer fitted with a "caloric" engine, as he called it—a hot-air engine really—on his principle, was built and successfully tried. This engine was designed to develop as much as 600 horse-power. His patent is dated 1826. You have in Fig. 17 (p. 726) a copy of the patent drawing. You will see that the engine shown here, is a mixed air and steam engine. The atmospheric air, or a portion of it, having first been used for the combustion of solid fuel under a steam boiler, was thereby heated and was afterwards used, together with the hot gases produced by combustion, to act in an ordinary working cylinder, and thus assisting the steam engine, In an alternative engine described in this patent, the hot products of combustion could be mixed with the steam from the boiler, and the two together could be used in the same cylinder of the engine.

You will realise that the essence of this invention of Ericsson's, as compared with that of Stirling, is that in Ericsson's engine a portion of the air was passed directly through the fire, and the gases of the products of combustion themselves were used directly in the power cylinder, and were exhausted after completing their work, while in Stirling's engine the air was heated, as I have shown you, first by the regenerator and then by being brought into contact with a hot diaphragm or plate of metal, the fire being on one side of this and the air upon the other, the two not coming directly into contact with each other; further, the air was not exhausted at the completion of each stroke, but was used over and over again. Broadly speaking, these two engines represent the two great classes of hot-air engines:—

In the one, the air to be used in the power cylinder, is passed directly through the fire, and goes, with the gases produced by combustion, into the power cylinder.

In the other class, the air does not come into direct contact with the fuel, but is heated through an intervening plate of metal.

In an engine of either class, a fresh charge of air may be drawn in for every stroke, the air may be used under an initial pressure, or at atmospheric pressure, and may be exhausted from the engine when it has done its work, or the same air may be used continually, the power then being obtained by heating and cooling it for each stroke.

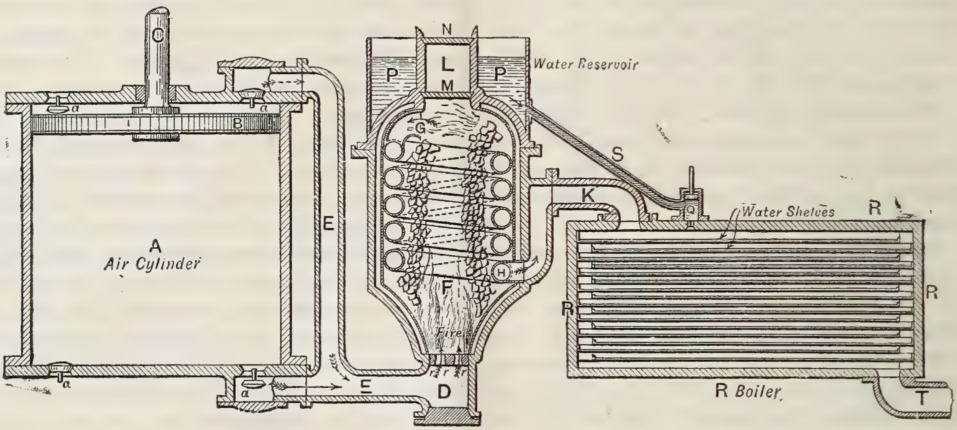
These hot-air engines of Stirling's and of Ericsson's—the earliest as they were—contain all the elements of practical success which, so far as we now know, are capable of being usefully employed in similar engines.

If this is so, you may ask me—Why did they fail to become more popular? Well, they failed from practical reasons—practical difficulties arising from working and manufacture; and as these practical difficulties and practical reasons are those which limit the useful effect to be obtained from any hot-air engines—popularly so-called—it may be as well to briefly consider them at this stage.

As I have said, Stirling's engine had the heat transmitted to the working agent—the air—through the thickness of the cast-iron air vessel shown on the diagram.

Now air is, practically, very difficult indeed to heat; it is one of the worst conductors of heat we know, and it is impossible in such an

Fig. 17.—Ericsson's Hot-air Engine.



engine to transmit the necessary quantity of heat to the air sufficiently rapidly, unless the surface exposed is very large.

Very low maximum temperatures, as a fact, are obtained with engines such as the "Stirling," where the heat is transmitted through the thickness of a metal plate. In a Stirling engine indicating as much as 37 horse-power, the maximum initial temperature was only about 650° Fahr., and the final temperature only about 160°, and to obtain this difference of temperature a machine, or engine, was required so bulky as to weigh a little more than one ton for each indicated horse-power that was obtained. In the steam engine of a torpedo boat the indicated horse-power is obtained from as small a weight as 45 lbs., including in this the proportion of weight of the boiler and of its water.

Further, the high temperatures to which the heating vessels of such hot-air engines must be subjected in order that the temperature of the air shall be raised as high as possible, cause these vessels to be rapidly burnt out and destroyed.

You may say that, if this plan of working of Stirling's, where the heat was transmitted through a metal plate, was a failure, why not let the fire burn directly in the air which has to be heated, still using this air under an initial pressure as Stirling did? This plan has been tried in the Wenham engine—one of the most successful of the more recent hot-air engines—and in other similar engines; but, on consideration, you will see that this plan has also its disadvantages. You will see that the air, after it has passed through the fire, and has done its work, must be exhausted from

the engine, for fresh air is required to support combustion, thus losing that portion of the heat taken away in the air when it is exhausted. You will also see that as the fire must be stoked, or, in other words, as fresh fuel must be supplied to it, this must be done without permitting the air which is under pressure to escape. Further, it is found, in practice, that where the fire is directly in contact with the air used for a working agent, this air takes up, in its passage through or over the fire, grit and ashes, which cause friction and rapid wear in the metal surfaces in moving contact.

This brings me to the question of lubrication, which has been a source of great difficulty. With the high temperatures, which can alone be economical, either lubrication is insufficient, with the result that the friction is great, or if lubrication is at all satisfactory, then it can only be carried out at great cost, and with some such material as plumbago.

One further and almost insuperable practical difficulty connected with this class of hot-air engines has been found, and that is the difficulty of keeping the various joints tight, and avoiding leakage. The high and constantly varying temperatures cause unequal expansion of the metals of which the heating vessels and working cylinders are composed, with the result that these are warped and twisted. Further, it does not at all follow that a joint which is satisfactory when the metals in contact are cold, and is then capable of standing sufficiently high air pressures, will be equally satisfactory when the metals are hot, or when they are subjected to numerous and rapid variations of temperature. In addition to this, a leakage of air, which is (unlike a leakage of steam) invisible, is not so simple a matter to detect; and thus the leak may only make its presence known by the lessening of the pressure and of the speed of the engine, or by its stoppage altogether. Again, in this class of hot-air engines, where the air is used under initial pressure, valves of some kind are absolutely necessary, and these are great sources of trouble, the difficulty being to keep them tight. The high temperatures cause warping, and the ashes and grit cause scoring, of the surfaces in contact.

Professor Rankine, in his work on the steam engine, discussed very fully the various advantages and disadvantages to be obtained from the use of hot air in motive power engines. The theoretical conclusions at which he arrived were strongly in favour of such engines, but the practical difficulties I have enumerated, and other minor practical difficulties which exist, have up to the present prevented an extended use of hot-air engines except for small powers.

In the two forms of hot-air engines which are most generally in use now-a-days in England, the design is such as to eliminate most of these practical difficulties, but even in these the power obtained is small in comparison with the weight of the engine.

I have thought it well, in order to enable you the more readily to follow the description of these two forms of hot-air engine, to provide you not only with diagrams but to have working models prepared, showing the relative movements of the pistons and displacers.

The "Rider" engine is one which is, as I have said, at present largely used for small powers. It illustrates very satisfactorily the various advantages obtained in those engines where the air is used over and over again, and is never exhausted from the engine, being heated by the external application of heat to a vessel or cylinder in which the air is contained.

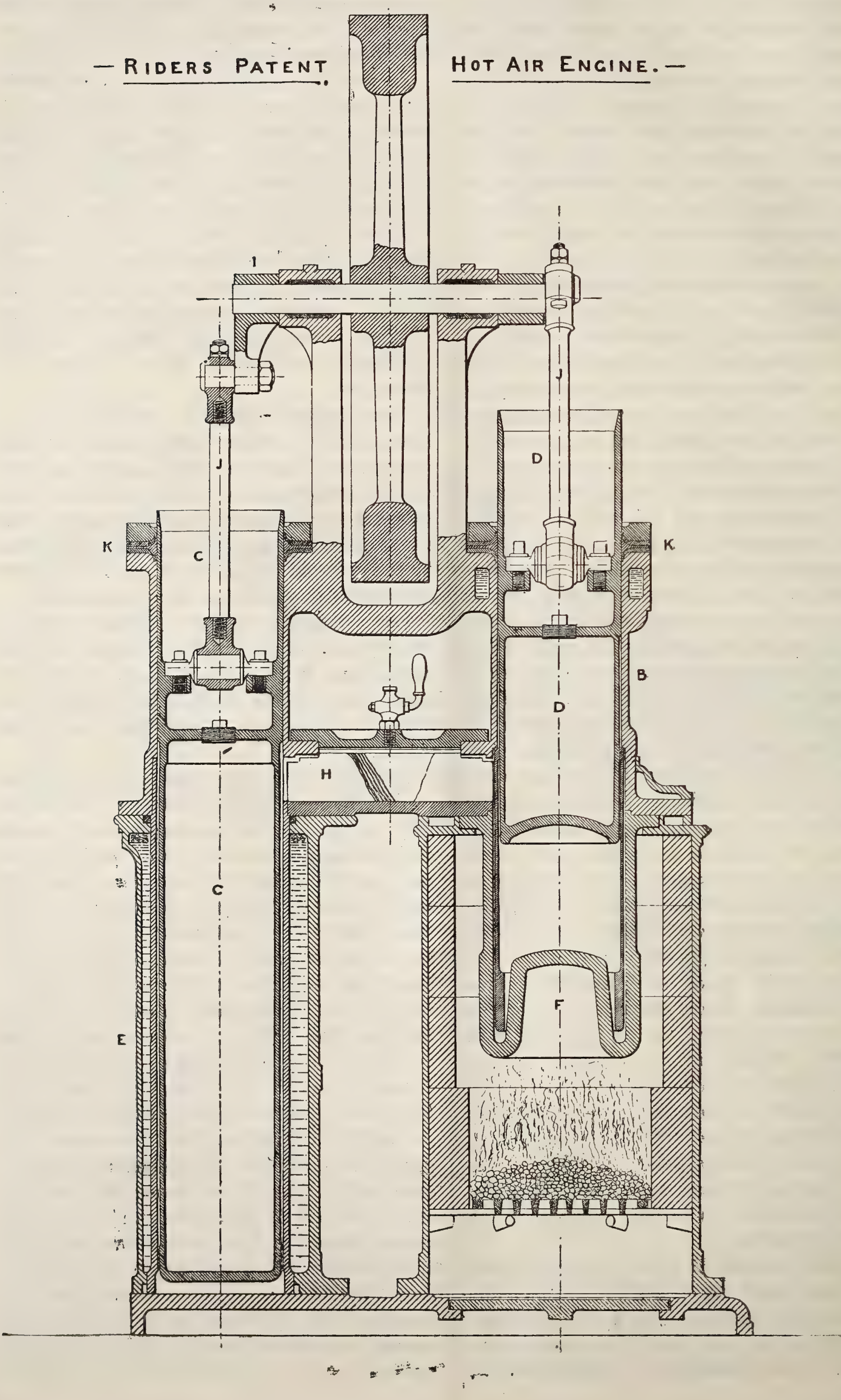
I have here a working cardboard model of this engine. There is also a large wall diagram, and you have in Fig. 18 (p. 728) a reduced fac-simile of this. But let me ask you to look at the working cardboard model.

You will see from this that there are two vertical cylinders, each of which has in it a piston, or plunger, their strokes and diameters, however, not being equal; that in the power cylinder, in which the air is heated, being the larger. One of these (that to the left hand), lettered C, may be called the compression plunger, or displacer, and the other to the right, lettered D, may be called the power plunger. You will see that from each of them a connecting-rod is taken, these rods being coupled to two cranks, one on each end of the crank shaft, this shaft carrying the fly-wheel in the middle of its length. The cranks are placed at such an angle with regard to each other, that when the one marked C is at the bottom of its stroke, the crank of the power plunger, D, is slightly above the middle of its stroke. You will see that under the power cylinder there is the fire, and surrounding the cylinder in which the displacer, C, works, there is a water jacket for cooling.

FIG. 18.

— SECTION. —

— RIDERS PATENT HOT AIR ENGINE. —



Let us now move this working model, and let us place the plunger, D, at the bottom of its stroke.

You will see that the plunger, C, is now slightly below the half-stroke upwards. You will also see that between the two cylinders there is a passage, H, open at all times to both the cylinders, and having in it a series of thin wrought-iron plates placed very close to each other, so as to form "the regenerator"—the air in passing backwards and forwards from one cylinder to the other having always to pass through this regenerator. We have here, therefore, two vessels, one kept hot the other kept cold; the capacity of these vessels capable of regular variation (not only as regards each vessel, but, in some parts of the stroke, as regards each other) by the movements of the plungers, and in the passage between the two vessels there is the regenerator for storing up and giving out the heat from the air passing to and fro.

Now, the plunger, D, being at the bottom of its stroke, and the fire being lit, and this portion of the apparatus being made completely hot, the air below it is heated, expands, lifts the plunger, D; further air is driven in from the other cylinder by the descent of the displacer, C, through the regenerator and around the pendant liner in the cylinder, F; is also heated until the plunger, D, is driven to the top of its stroke. At this time the compression plunger, or displacer, C, is at the half-stroke upwards, and as the engine moves on, the power plunger comes down, and hot air from the power cylinder, F, is driven through the regenerator, where, until it has time to cool in the compression cylinder, it acts to force the displacer upwards, assisting therefore the momentum of the fly-wheel to bring the power plunger downwards. By the time the power plunger is at the bottom of its stroke all the air has passed into the compression cylinder; has been cooled; and has thereby had its volume reduced; then the momentum of the fly-wheel carries the crank shaft on; the displacer is brought downwards; the air—passing from the compression cylinder back to the power cylinder through the regenerator—picks up the heat which had been left behind in this; has fresh heat added to it from the hot sides of the power cylinder (against which it is forced by the pendant cylindrical liner in this cylinder) is by this heat again increased in pressure under the power plunger; forces this plunger upwards. This "cycle" of operations is continously repeated as the engine works.

I have here also a working cardboard model of the "Bailey" hot-air engine. In this case we have only one vessel or cylinder, having within it the working piston and another longer piston called the displacer. At one end of this vessel the fire is placed, and at the other end there is a water jacket through which a continuous current of cold water is kept circulating. The action, as you will see, is somewhat similar to that of the Rider engine, the two pistons, however, working in the one cylinder.

You will note that in neither of these engines, which are, as I have said, among the most successful and most largely used in England at the present day, is there any valve through which the air has to pass in order to go from that part of the apparatus where it is heated to that part of the apparatus where it is cooled; and, further, the only moving parts exposed to the hottest air are those in which there is no direct frictional contact between the surfaces. These engines, therefore, both of them, are free from the difficulties arising from valves subjected to the necessary high temperatures, and are also, to a very large extent, free from the difficulties of lubrication of surfaces subjected to such high temperature.

An engine has recently been devised—and I believe experimental runs are now being conducted with it—differing from both of these, for in it the air is used under an initial pressure; a portion of it is passed directly through the fire, the remainder passes into the engine with this, and mixing with the first air and with the products of combustion from the fire, together go to work the power plunger directly, being then exhausted from the engine, and a fresh charge of air drawn in at each stroke. A portion of this fresh charge of air is, as I have said, passed through the fire, but the remainder is delivered round the upper part of the power cylinder above the fire, and spreading itself round the power piston, which has—as the Rider engine has—a long pendant part below that which is in frictional contact with the side of the cylinder, sweeps downwards in the narrow space between the two, thereby (it is said) sweeping away the grit and ashes, thus preventing the excessive wear usually found to arise from these, and allowing of ample and efficient lubrication of the surfaces in contact. In this engine, as I have told you, it is necessary (as the fire is burning in the air under pressure) that the fresh fuel shall be added without allowing

escape of air. This is accomplished in an extremely ingenious manner by the engine itself, automatically, and at intervals (the fire having been once started), through what is technically known as an "air lock." A fairly full description of this engine is to be found in the journal—*Industries*, for the 22nd March last, and to this I must refer those of you who wish to further consider this engine.

Time will not allow of any more lengthy description of the details of construction of the various other forms of hot-air engines. The one which I have last described appears to me to contain within it the elements of possible future success.

We will conclude this portion of our subject and our lecture for to-night by investigating, for some few minutes, the efficiency which has, up to the present, been obtained with hot-air engines, comparing this efficiency with that of the steam engine which we used last week.

We must do this by taking as the basis for our comparison, the 11 per cent. of efficiency of the steam engine, because that represents the per-centage of effect obtained from the solid fuel which is put into the furnace of the steam boiler; that is to say, we must as far as the steam engine is concerned, include and not exclude the boiler, and we must do this because in hot-air engines solid and not gaseous fuel is the fuel which is generally used; because it is burnt in a furnace similar to that of the steam boiler furnace, similar in its losses and its advantages.

So far as I can gather, the large engine of Ericsson—the one of which I have spoken as developing some 600 horse-power—consumed as much as 6½ lbs. of coal per indicated horse-power per hour; more than four times as much, therefore, as is consumed in a steam engine similar to that constructed by Messrs. Davey Paxman and Co., and tried by the judges in the Motor Trials of which I showed you the "balance-sheet" this evening.

The lowest record that I find of consumption in a hot-air engine is that in connection with the celebrated engine of Stirling, which drove the machinery at the Dundee Foundry for upwards of three years. This had a working cylinder 16 inches diameter and about 4 feet stroke, made about 25 to 29 revolutions per minute, and indicated some 40 horse-power. Fairly careful trials were made with this engine, with the result that it was found to consume some 2½ lbs. of coal per indicated horse-power per hour. This engine worked at the Dundee Foundry, doing the whole work of driving the factory for some three years; but it was then laid aside, because the heating vessels had by that time been entirely destroyed, owing to the high heat to which it was necessary to subject them in order to obtain the above power.

I think the hot-air engine—always using that term in its popular sense, and not in its truly scientific sense—is a striking example of how theory and practice are, at times, at variance. Theoretically, the mechanical efficiency of these engines should be very much higher than that of the steam engine, but owing to the many practical difficulties of which I have told you, their mechanical efficiency is, as we have seen, very much lower.

I think, as the result of what we have learnt this evening, you will agree with me that, although there may be special cases and special circumstances which will justify—in fact, compel, if I may so put it—the use of a hot-air engine, yet it is not at all probable that such engines will supersede the steam engine for large powers; that it is only for small powers these engines will be at all largely used; and that for large powers they are practically, from an economical point of view, unusable.

It is not, in my opinion, therefore the hot-air engine which is, in the near future, to supersede the steam engine.

Miscellaneous.

NEW LONDON PARKS.

In No. 1,862 of the *Journal* there was given a list of the "Open Spaces of London," which have been secured as permanent parks or gardens* free to the public. The most important of the many additions since the list was in type is the presentation by the freeholder of 14 acres of "Myatt's Fields," Camberwell, which, under the supervision of the Metropolitan Public Gardens' Association, has, at a cost of

* The smaller improvements include the laying out of the Tower-gardens, at a cost of £1,000; the opening of Edward-square, Caledonian-road; the grounds of St. Alban's, Fulham; St. Clement's, Notting-hill; Trinity Chapel, Poplar; and the planting of trees in twenty small churchyards by the Metropolitan Public Gardens Association.

nearly £10,000, been laid out as a park, and was opened for use on May 28th. It lies about 200 yards south-west of Camberwell Station.

On Wednesday, 17th July, a public park of 18 acres was opened by Lady George Hamilton at Acton. The ground was purchased at a cost of £25,000, towards which the Goldsmiths' Company contributed £5,000.

On Wednesday, 24th, Clissold-park (52½ acres) was opened by the Earl of Rosebery. The cost of the park was £95,000.

Ravenscourt-park (near Shaftesbury-road Station), 30 acres, the purchase and laying out of which cost £58,000, was opened last year.

A proposal has been again laid before the public, by a committee,* to purchase Brockwell-hall, Herne-hill, with 78 acres of the surrounding park. The entire Brockwell property is 130 acres, and on it stand, in addition to the hall, Brockwell-house and Clarence-lodge, both having extensive grounds shortly to be used for building. It has been ascertained that the 78 acres can be purchased at £1,500 per acre, provided the amount raised within six months from the date of signing the provisional contract is sufficient to warrant an actual contract. The sum asked not long ago was £3,000 per acre. With a grant of £25,000 from the Charity Commissioners, £61,000 voted by the County Council, and a more recent grant of £20,000 voted by the Lambeth Vestry, the committee feel a confidence that their scheme will prosper.

This proposal is one of more than local importance. The position, character, and size of the park mark it out as something more than a site for a garden for the ratepayers, and a playground for the children of the immediate district.

Its main entrance, which adjoins Herne-hill Station, is within the four-mile radius from Charing-cross, and is barely over a two-mile drive from Vauxhall-bridge, by broad roads little impeded by traffic. By rail it is within 12 to 15 minutes (according to quick or stopping trains) from Victoria, Ludgate-hill, or London-bridge. Trams from Vauxhall to Norwood pass the lodges, and the three lines of trams to Brixton-hill put passengers down within about five minutes' walk. There is no park in the suburbs so readily accessible from so many parts of London.

The tall elms, with their rookeries, which belt the park, are probably familiar to those who have driven out from the West-end, past Brixton Church to the Dulwich Picture Gallery. The lower part of the ground, along the Norwood-road, is a wide strip of "Woolwich and Reading beds," above which rises, in a gentle slope, the "London clay," its highest point crowned with the hall, and then extending with gentle undulations to Tulse-hill. On the alluvial of the London clay slopes are many fine oaks, which, with the exception of those in Kensington-gardens, are the only groups of oaks so near the centre of London. There has been no attempt anywhere at gardening or the formation of shrubberies, and except the roads up to the hall from the two lodges, there are no paths. The whole park is grass dotted with groups of trees. There are three or four little natural ponds where fallen trees remain as they fell. The aspect of the place is that of an old park left quite to itself since the beginning of the century. Although the metropolis has many trimly kept parks, bright with carpet bedding and masses of foliage, some even diversified with sub-tropical plants, it is difficult to find in them any spot which gives that restful idea of being in the country, such as Richmond-park affords. In this respect, Brockwell, as a London public park, would be unique, for even on Easter Monday (when it was for the day thrown open for inspection), with no leaves yet out, it was observable in many parts how completely all surrounding buildings were lost sight of, except a church spire suggestive of a neighbouring village. Now that the trees are in full leaf it is difficult, among such secluded rural views, to realise that Trafalgar-square is but four miles away. The knoll on which the Hall stands, however, reveals, by its wide views, the position—views which extend to Harrow and Hampstead, to the Sydenham range, and far up and down the Thames valley. The height of this above sea level is given as 237 feet.

From the size of the park, the lower parts afford ample space for cricket ground, gymnasia, and asphalte paths for perambulators, without interfering with the seclusion of the upper undulations, so that while part of the 78 acres might furnish a local recreation ground on a large scale, the higher portions might give London a public natural park such as it does not at present possess. As a place for a hour or two's quiet rest, without the fatigue of a long journey, its value from a health point of view would be very great.

The 72 acres of the Dulwich estate set apart for a public park, and for which the roads are already formed, though low-lying land as compared to Brockwell, is attractive from its oaks, and is already practically in use, though not fully laid out.

* The chairman is T. L. Bristowe, M.P., and the Hon. Sec., Mr. A. C. Harris, 32, Saltoun-road, Brixton, S.W.

PRODUCTION OF ESSENCE OF LEMON IN SICILY.

Lemons in Sicily are divided into two classes, the true lemon and the bastard lemon. The United States Consul at Messina says that the true lemon is produced by the April and May blooms, the bastard by the irregular blooms of February, March, June, and July, which depend upon the rainfall or regular irrigation, and the intensity of the heat during the summer and winter seasons. There are but three harvests of the true lemon; the first is the November,

cut when the lemon is green in appearance and not fully ripe. Lemons of this cut are the most highly prized; they possess remarkable qualities for keeping, and are admirably preserved in boxes or warehouses from November until March, and sometimes as late as May, and then shipped. The second cut occurs in December and January, and the third in March and April. Bastard lemons present well-defined peculiarities in shape and appearance; their inner skin is fine, and adheres tenaciously to the fruit; they are hard, rich in acid, and seedless. The bastard lemon produced from the bloom of June is still green the following April, and ripens only towards the end of July. It remains on the tree over a year. The true lemon can be left on the tree until the end of May or the first week in June, but it interferes with the new crop, drops off from over-maturity, and is liable to be attacked by insects. The bastards, on the contrary, withstand bad weather and parasites, and they mature from June to October. In obtaining the essence from the lemon the following operations are performed by the Sicilian workmen. He peels the fruit lengthwise with three strokes of a sharp knife, and lets the peel fall into a tub under the chopping-block. He then cuts the lemon in two, and throws it from his knife into a bucket. He works with wonderful rapidity, and fills from 10 to 12 tubs with peel a day, and is paid about 2½d. a tub, weighing 77 lbs. His left hand and right index are protected with bands of osnaburgs or leather. Decayed fruit is not peeled. Fresh peel is soaked in water 15 minutes before the essence is extracted. Peel that has stood a day or two should remain in soak from 30 to 40 minutes, so that it may swell and offer a greater resistance to the sponge. The operative holds a small sponge in his left hand, against which he presses each piece of peel two or three times, simple pressure followed by rotary pressure. The women employed in this work run a piece of cane through their sponges to enable them to hold them more firmly. The outside of the peel is pressed against the sponge, as the oil glands are in the epicarp. The crushing of the oil cells liberates the essence therein contained. The sponge, when saturated with the essence, is squeezed into an earthenware vessel which the operative holds in his lap. He is expected to press the peel so thoroughly as not to overlook a single cell. This is ascertained by holding the pressed peel to the flame of a candle; should it neither crackle nor diminish the brilliancy of the flame, the cells are empty. This process yields, besides the essence, a small quantity of juice and dregs. The separation of the essence, juice, and dregs soon takes place if the vessels are not disturbed; the oil floats on the juice, and the dregs fall to the bottom. These three products derived from the peel have no affinity with each other. As the essence rises to the surface, it is skimmed off, bottled, and left to settle for a few days. It is then drawn off with a glass syphon into copper cans, which are hermetically sealed. After the essence has been expressed, a small quantity of juice is pressed from the peels, which are then either given as food to oxen and goats, or thrown away The yield of essence is very variable, and the industry is carried on five months in the year. Immature fruit contains the most oil. From November to April, in the province of Messina, 1,000 lemons yield about 14 ounces of essence, and 17 gallons of juice. An operative expresses three baskets of lemon peel (weighing 190 lbs.) a day, and is paid at the rate of about 10d. a basket. The essence is so valuable, that the operatives are closely watched. Six men can work up 8,000 lemons a day; two cut off the peel, while four extract the essence, and obtain 136 gallons of lemon juice, and 7 lbs. of essence. In the extraction of essence, defective fruit—thorn-picked fruit, blown down by the wind or attacked by rust—is used. This fruit is sold by the "thousand," equivalent to 119 kilogrammes, and thus classified:—(1st) Mixed lemons as they come from the groves during December and January, of good quality but not always marketable, often from top branches; (2nd) lemons from March blooms; (3rd) lemons refused at the packing houses; (4th) dropped fruit; and (5th) shrivelled or deformed fruit. Lemons grown on clay soil yield more essence and juice than those grown on sandy or rocky soil. Dealers sometimes adulterate their essences with fixed oils, alcohol, or turpentine. Adulteration by fixed oils is detected by pouring a few drops of essence on a sheet of paper, and heating it; upon the evaporation of the essence a greasy spot will remain. Alcohol is detected by pouring a few drops of the essence into a glass tube in which a small quantity of chloride of lime has been dissolved. The tube is then heated, and well shaken, and its contents being allowed to settle, the essence will float on the denser liquid. For the production of raw and concentrated lemon juice, the following is the system employed. When the lemons have been peeled and cut in two, as described above, they are carried to the press and thrown into large wicker bags, circular in form, and then well pressed. If the juice is to be exported raw, only perfectly sound lemons can be used; but if the juice is to be boiled down, one-fifth of the lemons may be of an inferior quality. The juice from sound lemons is yellowish in colour and has a pleasant aroma; its density decreases with age. With all classes of lemons the yield of juice and its acidity varies considerably from month to month. The amount of juice increases from October to April, its acidity and density decrease, and the same is the case with the density of the essence, owing to winter rains. An addition of 5 per cent. of alcohol will prevent raw lemon juice from spoiling. Lemon juice is adulterated with salt or tartaric acid. Raw and concentrated lemon juice is exported in casks of 130 gallons capacity. It requires about 1,500 lemons to yield 26 gallons of juice, while it takes 2,500 to yield the same quantity of concentrated juice, and 2,000,000,

more or less, according to their acidity, to give a cask. Experience has shown that the lemons of the province of Messina, especially from the eastern shore, contain more acidity than the lemons grown elsewhere in Sicily. The value of lemon juice is governed by its acidity. The rule is that concentrated lemon juice shall show 60 degrees of acidity (the juice extracted from the bergamot or the sour orange must show 48 degrees, or one-fifth less than that derived from the lemon; it also sells for one-fifth less than lemon juice). Formerly a citrometer, known as Rouchetti's gauge, was used to ascertain the per-centage of acidity; now, however, resort is had to chemical analysis, which is said to be more satisfactory both to buyer and seller. Of late years a new article, known as vacuum pan concentrated natural juice of the lemon, has been manufactured at Messina. The juice concentrated by this method contains 600 grains of crystallisable citric acid for every quart. It is exported in casks containing 112 gallons, and in half and quarter casks. It is also shipped in bottles of 500, 300, and 150 grains each. Consul Jones says, in conclusion, that there is an establishment at Messina, probably the only one of its kind in Italy, in which crystallised citric acid is prepared. It takes from 340 to 380 lemons to make a pound of citric acid, which sells at about 1s. 9d. The quantity of essence of lemon exported from Messina during the year 1887 amounted to 440,000 lbs. avoirdupois, valued at £125,000; while of lemon juice 4,438 pipes were exported during the twelve months ended November 30th, 1887.

REPUBLICS OF VENEZUELA AND PARAGUAY.

In connection with the Paris Exhibition there are published numerous descriptive and general statistical details respecting the exhibiting countries. Those of the several South American Republics, Venezuela, Mexico, Nicaragua, Bolivia, Guatemala, Paraguay, &c., contain much official information of importance.

From a pamphlet on Venezuela, issued in five languages, the following particulars are gathered:—The population on the 1st January, 1886, was a little over 2,000,000. The country is divided into three distinctly marked zones, the agricultural, pastoral, and forest. The first comprises the plantations of sugar-cane, coffee, cocoa, cereals, &c.; the second, or grazing zone, covered with gigantic grasses, affords good runs for the numerous herds of cattle, of which it is the special region. In the last, or forest zone, many important commercial products grow wild, such as caoutchouc, the trees yielding tonquin beans, copaiva balsam, Brazil nuts, and piassaba fibre, as well as the vanilla orchid. Numerous palms and fibre plants embellish this zone.

Primary education is gratuitous and obligatory, and there are in the Republic close upon 2,000 schools, with 100,000 scholars. There are in all 68 universities, Federal colleges, and other high-class and superior educational institutions, with 594 professors and 4,380 students.

There are in the country 220 kilometres of railway open, and 407 more in course of construction, and contracts are being made or arranged for nearly 2,000 kilometres more. There are 133 newspapers published in the Republic. The telegraph lines extend over 4,179 kilometres. Agriculture supplies both an import and industry, owing to the numerous and extensive pasturages of the country. The census of 1887 gave the numbers and description of live stock as follows:—

Cattle	5,275,481
Goats and sheep	4,645,858
Horses and mules	622,306
Asses..................	769,920
Swine	1,439,185
	12,752,750

The number of cattle has quadrupled in the last ten years; a large trade is carried on in the export of cattle to Trinidad and other quarters; 7,000 head were shipped in 1886.

Until lately the territory of Venezuela was scarcely known as a mining country, but since 1866 it has shown in the markets of the world the fabulous wealth it possesses, not only in the precious metals, but also in other valuable and useful minerals. In fact, gold, copper, silver, iron, lead, tin, sulphur, petroleum, kaolin, and asphalt are abundant in Venezuela. The produce of all the mines in 1886 was of gold, 7,272 kilos; quartz, 2,894 kilos; copper, 20,620,570 kilos; other minerals, 21,584 kilos. The total value of these is given at £1,142,000. Several companies are at present engaged in working the gold of Guiana, some of which have been so far successful that this Venezuelan region is rightly considered to be the genuine El Dorado.

The Callao Company, the most important of all, has, since its foundation in 1871, produced 911,015 ounces of gold up to 1885. It was established with a small capital, under £13,000, in 322 shares, and has yielded to the shareholders in fifteen years, in dividends and share value, the fabulous sum of £8,340.

The product of gold since 1866 (when the rich mines of Guiana commenced to be generally worked) to 1885 is shown by the official exports from Ciudad Bolivar to have been 1,730,712 ounces.

The celebrated copper mines of Aron continue to be worked by the English company which commenced in 1875. From 1880 to 1886, 143,000 tons of copper were exported to England. The general and coasting trade was carried on in 1886 by 9,263 vessels, aggregating 2,052,140 tons, of which the

Venezuelan flag formed the chief, comprising 7,568 vessels of 169,440 tons. The German, North American, French, Dutch, and English vessels carry on the principal trade in the order stated. The principal exports in 1886 were—copper, 99,000,000 kilos; cocoa, 5,000,000 kilos; hides and skins, about 3,000,000 kilos; divi-divi, for tanning, 2,375,364 kilos; sugar, 500,000 kilos; dye-woods, 1,220,000 kilos; timber, 6,872,556 kilos; copaiva oil, 31,370 kilos; caoutchouc, 18,856 kilos; cotton, 123,670 kilos; tonquin beans, 76,279 kilos; annotta, 4,100 kilos; tobacco, 71,000 kilos; and straw hats, 2,000 kilos.

Of the isolated interior South American republic of Paraguay the following details are given. The population of the Republic, according to the census of 1886, was but 329,688, of whom the foreigners number but 30,000, and are chiefly Italians, Brazilians, Spanish, Portuguese, and French. There are only 39 English. Assomption, the capital, has 25,000 inhabitants.

The cultivation of maize, manioc, the sugar-cane, beans, ground-nuts, and cotton is large, owing to the fertility of the soil. The holly, which furnishes the *yerba mate*, or Paraguay tea, is not a culture, but grows wild in the forests. The production in 1886 was 900,000 arrobas, of a quarter of a cwt. each. The live stock of the Republic comprises 730,000 horned cattle, 62,386 horses, 32,351 sheep, 12,250 swine, 11,102 goats, and 4,164 asses and mules.

Tanning is an important industry, as tanning barks are abundant. The manufacture of *ponchos*, or woollen cloaks, is a local industry; some of these fetch fabulous prices, according to their fineness and ornamentation.

Paraguay produces chiefly the raw materials of commerce, and from its isolated position has only indirect relations with Europe, Monte Video and Buenos Ayres monopolising most of the trade. The exports consist chiefly of tobacco 7,000,000 kilos, 25,000,000 cigars, Paraguay tea (a large article of consumption in the neighbouring South American States), 6,000,000 kilos being exported, about 100,000 hides, 50,000,000 oranges, and 500,000 cubic metres of timber, in 1886. There are five newspapers published in the capital, and two lines of tramways; but there are only, at present, about 73 kilometres of railway, but extensions are projected. The two banks of the river Paraguay are covered with palms of different species. Fish are abundant, and of excellent quality.

EXPORT OF EGGS FROM RUSSIA.

The *Board of Trade Journal*, quoting from the *Journal de la Chambre de Commerce de Constantinople* for the 22nd of June, says that the Russian Minister of Finance has recently published the following particulars respecting the export of eggs:—

The principal market for this article is England, and especially London. There were imported into this city, in 1883, 800,000,000 of eggs, valued at 25,954,000 roubles; in 1884, 993,000,000, worth 27,649,000 roubles; in 1885, 1,002,000,000, worth 27,846,000 roubles; in 1886, 1,033,000,000, worth 27,350,000 roubles; and in 1887, 1,088,000,000, worth 29,265,000 roubles.

The average price of eggs on the London market has gradually fallen from 3 roubles in 1883, to 2·69 roubles in 1887, per 100. The eggs are imported into England from France, Germany, Belgium, Denmark, and Russia.

Italy does not figure among the above, because its produce generally passes through Belgium, and is necessarily shown as coming from that country. The same is, to a large extent, the case with regard to Russia, which sends the greater part of its products into Germany and into Austria-Hungary.

In eight years the export of eggs from Russia into these two countries have increased from 813,272 roubles to 11,589,000 roubles. During the period from 1881 to 1888, the average price of these exported eggs has increased about 50 per cent. (1·71 roubles against 1·20 per hundred).

Since 1886, Russia has exported, besides, the yolks and whites of eggs preserved in tins (44,348 pouds in 1886, and 45,946 in 1887). These articles are, for the greater part, sent to Germany and to France.

The principal markets for eggs in Russia are Kozlow, Riga, Orel, Warsaw, and Libau. Notwithstanding the large development of exports, the price of eggs has remained stationary at St. Petersburg and Moscow.

General Notes.

Institute of British Carriage Manufacturers.—The autumn meeting of the institute will be held at Newcastle-upon-Tyne, commencing on Monday, August 5th, for the reading and discussion of papers, &c., in the Lecture Theatre of the Literary and Philosophical Society. Members of the Society of Arts are invited to attend. Further information may be obtained from the local secretary, Mr. William Philipson, 9, Victoria-square, Newcastle-on-Tyne, who will be pleased to receive drawings, models, or specimen of materials used in carriage building, for the exhibition in the Arts Room of the College of Science.

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FRIDAY, AUGUST 9, 1889.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

"*OWEN JONES*" *PRIZES.*

This competition was instituted in 1878, by the Council of the Society of Arts, as trustees of the sum of £400, presented to them by the Owen Jones Memorial Committee, being the balance of subscriptions to that fund, upon condition of their expending the interest thereof in prizes to "Students of the School of Art who, in annual competition, produce the best design for Household Furniture, Carpets, Wall-papers and Hangings, Damask, Chintzes, &c., regulated by the principles laid down by Owen Jones." The prizes are awarded on the results of the annual competition of the Science and Art Department.

Six prizes were offered for competition in the present year, each prize consisting of a bound copy of Owen Jones's "Principles of Design," and a Bronze Medal.

The following is a list of the successful candidates:—

Maggie Strang, School of Art, Glasgow.—Design for surface decoration.

Mary K. Curtis, School of Art, Canterbury.—Design for damask.

Lizzie Girvan, School of Art, Glasgow.—Design for wall paper.

Arthur M. Pearson, School of Art, Cavendish-street, Manchester.—Design for the decoration of a room.

William H. Pegg, School of Art, Nottingham.—Design for lace curtains, &c.

Ellen Robinson, School of Art, Scarborough—Design for tiles.

The next award will be made in 1890, when six prizes will be offered for competition.

Proceedings of the Society.

CANTOR LECTURES.

HEAT ENGINES OTHER THAN STEAM.

By H. Graham Harris, M.Inst.C.E.

Lecture III.—Delivered May 20th, 1889.

Syllabus.

Gas Engines — History — Lenoir — Hugon — Electrical Firing—Direct Flame Firing—Otto and Langen—Bischoff—Compression—Crossley—Crossley's Igniter — Clerk — Atkinson — Griffin — Other engines—Turning Effort on Crank Shaft—Possible Efficiency of the Gas Engine—Actual Efficiency—Losses—Practical Difficulties—Modes of overcoming these — Suggestions for Improvement — Crossley's Compound Gas Engine—Turning Effort on Crank Shaft—Application of the Regenerator — Siemens' Regenerative Gas Engine—Dowson Gas—Water Gas.

That which we have to do to-night is to consider the gas engine; the most commonly used form (for power purposes) of "heat engine other than steam;" the one which has up to the present, in practice, given the most satisfactory results, and the one which is even now the thoroughly successful rival of the steam engine for small powers.

As most of you know, gas engines have received great consideration, both from scientific and from practical men. They have been subjected to experiment in almost every direction; and I suppose there is scarcely any apparatus used by the engineer which, as a fact, has been more elaborately investigated and discussed, and about which more has been written. There is no doubt that it is largely due to this, and to the increasing demand for an economical small-power engine, arising from the increasing needs of civilisation, that the gas engine owes its present advanced position. Further, there is no doubt it is in such engines, combining within them, as we shall find they do, the theoretical and the practical advantages necessary for a motive-power heat engine, that the elements of future success are contained.

The gas engine is the product of many minds, and of the long continued assiduous labour of many men; it is one of the best practical examples of the successful attention of the engineer to minor details It is

true it owes some of its rapid advance to its rival, the steam engine. The steam engine has enabled many improvements in the mode of performing mechanical work to be attained, and this has, no doubt, helped the development of the gas engine.

Although gas engines differ widely among themselves, yet they are alike in one respect, and that is they are all "internally fired" engines. In them the working agent is air, which is heated by the combustion of coal or other combustible gas mixed with it in the power-cylinder itself; *i.e.*, in all of them the heat is communicated to the working agent directly, and in the power cylinder itself, and the boiler, or its equivalent, is entirely absent.

Further than this, the true working agent—the air—is already a gas, and, therefore, none of the heat put into it, by combustion of the fuel with which it is mixed, is absorbed in the form of latent heat, as it is in the steam engine, where we have the fluid (water), which has to be turned into the gas (steam) before we can use it in the heat engine, requiring for this transformation a certain amount of "unutilisable" (if I may coin a word) heat. In the gas engine there is no absorption of heat due to this "latent heat of vapourisation." Theoretically, if we had materials of which we could construct the working cylinders of our gas engines which did not absorb any of the heat developed, and if we could overcome the consequent difficulty of premature ignition from the hot sides of the power cylinders, and other difficulties, such as I pointed out to you when talking of the ideal heat engine of Carnot, it should be possible to obtain nearly the whole of the efficiency due to the difference between the temperature of combustion of the mixture of air and coal gas used in the cylinder, viz., some 3,500° Fahr. absolute, and the temperature of the exhaust, which should then be at least as low as that of the atmosphere, say, 530° Fahr. absolute. It is needless for me to tell you such an efficiency as this is not likely to be attained.

Time will not allow of our considering the various theories which have been propounded as to the completeness of combustion of the gases in the engine cylinder, nor can we stop to consider the questions of disassociation of the gases due to the high temperatures of combustion. I shall only refer to these, in so far as they are illustrated by the results which are obtained in practice.

It is true of engineering matters, as it is of almost all other things in this world, that you cannot get something for nothing; and we shall find that, while the economical advantage of eliminating the boiler from the gas engine is apparent, yet, because we obtain this advantage, we are saddled with certain disadvantages, which to some extent counterbalance this. These disadvantages, which arise from eliminating the boiler, were of much greater importance in the earlier days of gas engines and of gas engine construction. I I will not delay about these now, but will deal with them as we get further on with this most interesting portion of our subject. Further, I told you last week that air was one of the worst conductors of heat which we know. This, which was a disadvantage in the hot-air engine, we shall find is a practical advantage in the gas engine.

The earliest gas engine of which I have been able to get any record is one proposed by a M. de Rivaz, who, in 1807,* described an engine which was to be used for driving a carriage on common roads. Hydrogen gas was the medium by which the heat was to be obtained, for at that time, as you are aware, illuminating gas was not known. From this time forward many patents were taken out, and many suggestions and investigations were made, but it was not until the years 1860-1861, when another Frenchman, M. Lenoir, patented and introduced his gas engine, that any noteworthy practical success was obtained. Lenoir was followed, in 1865, by Hugon, and many engines on both these systems were constructed and put into successful practical work, and some of them are at work even to this day.

The first of Lenoir's patents is dated 1860, No. 335. This engine consisted (as you will see from the sectional plan in Fig. 19), of an engine similar to an ordinary horizontal steam engine, having the piston, piston-rod, connecting-rod, and crank-shaft, which these engines usually have. On each side of the cylinder, however, there is a slide valve, each valve being worked by an eccentric, strap, and rod. These slide valves are not contained in cases or chests, as is the ordinary steam valve, but they are held against the faces on the cylinder by springs or adjustable screws. The mixed charge of gas and atmospheric air is brought to the cylinder by means of a pipe, which, in a

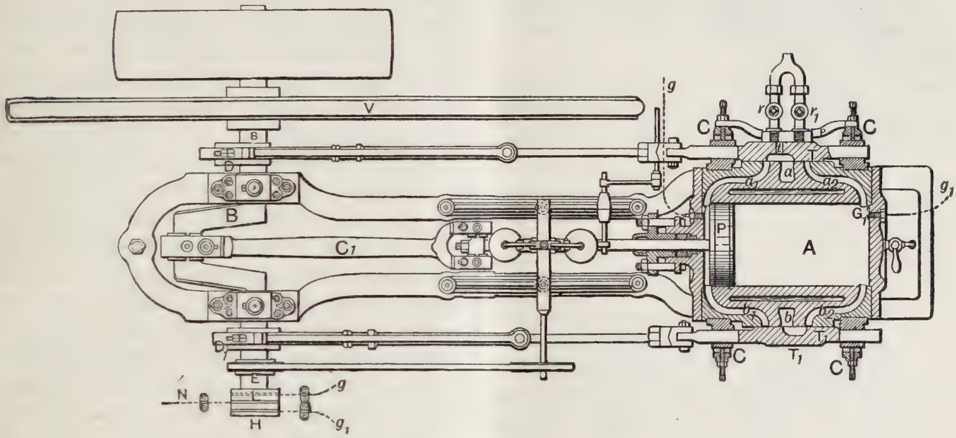
* Since the above was written, I find in a paper by M. Edouard Delamare-Deboulleville, read at the Paris meeting of the Institution of Mechanical Engineers in July of this year, that a reference to a gas engine was published by John Barber on the 31st October, 1791.

certain position, of that one of these valves which is the inlet, communicates through an opening directly with the cylinder. The exhaust takes place through the second valve, and the firing of the explosive mixture was done by means of an electric spark.

The engine worked as follows. The piston moved forward for a certain portion of its stroke, drawing in the mixed charge of gas and air, and then this charge was fired by an electric spark due to a contact made at the right moment by the engine itself, and the expansion of the hot gases propelled the piston to the end of the stroke. Thereupon the exhaust valve opened; the fly-wheel carried the engine on, and as the piston returned, a mixed charge of gas and air was drawn in on the front side of the piston; this charge was fired; the piston was driven back to the back end of its stroke; the exhaust valve for the front end of the cylinder was opened; the inlet for gas and air to the back end of the cylinder was then opened, as the fly-wheel carried the piston on, the fresh charge for the back end was drawn in; this was fired, and so on.

You will see that this was a double-acting

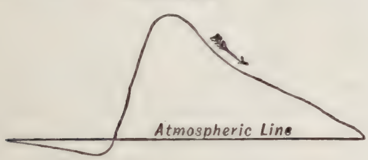
FIG. 19.—LENOIR'S GAS-ENGINE OF 1860.



Sectional Plan.

engine. I will ask you to look at the indicator diagram (No. 20) taken from one end of the cylinder of one of these engines, and you will there see that the piston in moving forward, during the first quarter of its stroke, was

FIG. 20.—LENOIR ENGINE—INDICATOR DIAGRAM.



drawing in the charge; that then the explosive mixture was ignited; the pressure rose; gradually fell as the hot gases expanded, till the piston reached the end of the stroke.

The Lenoir engine was practically similar to an ordinary high-pressure double-acting steam engine, with a valve arranged for the admission of an explosive mixture of gas and air at the ordinary atmospheric pressure at each end of the cylinder, and with means provided for igniting this explosive mixture electrically at the proper moment, and with another valve arranged to allow of the exhaust of the exploded gases. The great difference between the steam engine and the Lenoir engine being that in the latter about one-fourth of each stroke was inoperative for power purposes, the movement of the piston during this portion of the stroke being utilised to draw in to the cylinder the charge of explosive mixture.

There was provided around the cylinder of the engine a water jacket, through which cooling water was allowed to circulate, so that the surplus heat generated by the explosion might be carried off from the cylinder, and that thus the surface of the cylinder might be kept cool enough to allow of efficient lubrication.

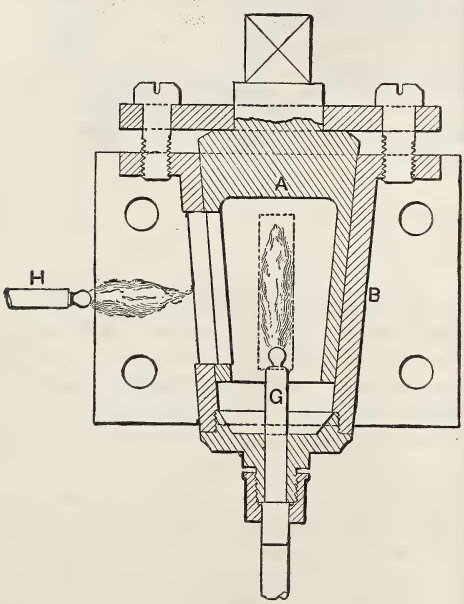
As I have told you, in this engine of Lenoir's, the explosion was caused—or, to use

the commonly accepted term, the "firing" was done—by an electric spark. Great difficulties were experienced with this in practice, as it required careful manipulation and adjustment, and frequently failed to cause explosion, or "missed fire."

The next engine of importance, that of Hugon, was, as I have said, patented in 1865, the patent being No. 986. The patentee states that the explosion or combustion of the mixture has hitherto been effected by an electric spark; and he says that the object of his improvements is to produce the explosion or combustion in another way with certainty, and at regular intervals. He proposed to do this by a modification of the lighting arrangement patented by Barnett in 1838, some 27 years earlier.

This arrangement of Barnett's is extremely simple to understand, and I will ask you to look at the diagram (No. 21) which shows it.

FIG. 21.—BARNETT'S IGNITER OF 1838.



You will see that in an ordinary tap there is a hollow plug, A, shown in its normal position, and that in this plug a gas-flame, G, is burning; this gas-flame being lit by the outside flame, H. Now the plug can be turned through a quarter of a revolution, and will thereby close the opening to the outside flame, and connect the inside flame through the opening shown in dotted lines with the working cylinder in which the explosive mixture is contained, thus firing that mixture; and, although the explosion may probably put out the flame which has been burning in the hollow plug, yet, when this plug is turned again to its normal position, the flame will be relit by the outside flame.

I remember, when I was in the "shops," as a precaution against fire, we were forbidden to bring matches into the works, and it was very often some little trouble to get a light, either in the early morning or in the evening, when gas was required. But if one burner in the shop was alight, we found no difficulty; for, taking a stop-ended handle off the slide-rest from a lathe, all that was required was to hold this well down over the gas burner which was alight. The handle became filled with gas, burning very slowly because the air necessary for combustion could not rapidly get at it, and it was possible, in fact common, to carry a light thus obtained the whole length of the shop, say some thirty or forty yards, and light another burner there.

I have here a stop-ended tube, and will hold it over this burner, and will try if I can light the one on the other side of the lecture table The principle thus illustrated, which, as you will see, is the one used by Barnett, is the principle by which the "firing" has been done till recently in almost all gas engines. I shall have to tell you of another mode which is now being adopted when we come to speak of the Crossley and of the Atkinson engines.

Another point of improvement of Hugon over Lenoir was connected with lubrication. When you remember that the temperature of combustion of the explosive mixture in the cylinder of a gas engine is generally assumed to be something like 3,000° Fahr., while the melting point of cast iron (the metal of which the cylinders are composed) is only about 2,000° Fahr., you will see that this question of lubrication is one likely to give trouble. I daresay you will wonder, if these temperatures are correct, why the gas engine cylinder is not melted. I will explain this to you presently, but for the moment must ask you to leave it; simply to take it for a fact that these temperatures do exist, and try to realise what must have been the lubrication difficulties. Hugon had realised these, and he suggested modes of solving them. The second claim of his patent is for "The employment in gas engines of arrangements for injecting water or other fluid capable of vapourising in the manner and for the purposes described." One effect of this would of course be to cool and to lubricate the cylinder and piston.

Although these engines of Lenoir and of

Hugon were to a large extent, as I have said, successful, yet the quantity of gas consumed in them was very much in excess of that which theory tells us is necessary, and was five or six times as much as that which is used to obtain an equivalent power in gas engines of the present day. The records of trials of these engines give the consumption as about 106 cubic feet per indicated horse-power per hour, instead of the 20 to 22 cubic feet, which we shall find is all that is required by present gas engines.

I will not occupy any more time in describing early engines, the description of these two is sufficient for our particular purpose, but I will come at once to the Otto and Langen free-piston engine, the engine which practically revolutionised the manufacture of this form of heat engine, and did so because it reduced the gas consumption from the 106 cubic feet, of which I have just told you, down to some 25 to 30 cubic feet.

I shall purposely neglect the Bischoff engine, as our time is so limited, and I shall do so although this engine attained a large measure of success; although it was fairly economical; and although it is even now successfully in use where very small powers are required. It is not, however, necessary to describe it, for if you fully understand the Lenoir and the Hugon and the various other gas engines which I must explain to you, you will thoroughly realise the principle on which the Bischoff engine works, and what it can do.

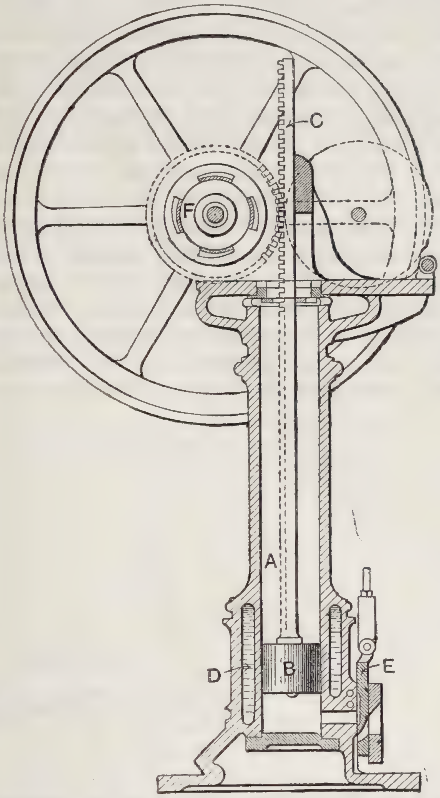
To revert to the Otto and Langen free-piston engine, shown in sectional elevation on Diagram No. 22. The idea upon which this engine is based is this:—

The cylinder is vertical, and the piston is not directly attached to the shaft, but can move from the bottom to the top of its stroke freely, *i.e.*, without exerting any power to turn the shaft. This piston was made heavy, and the explosion of the gaseous mixture blew it upwards in the cylinder, as a shot is blown along the bore of a gun, and it was only as the piston fell that any work was done in turning the shaft.

The means by which this free piston in its descent caused the shaft to revolve are shown upon the diagram of the clutch, Fig. 23.

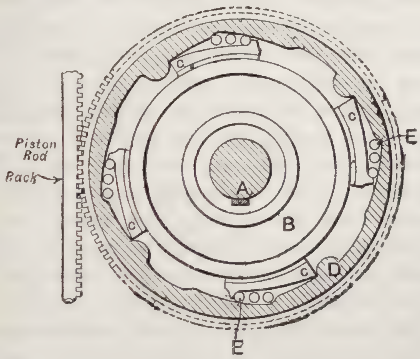
The piston rod of the engine had upon it a rack, and the outer portion of the clutch consisted of a toothed wheel, D, the teeth engaging with those of the rack. This toothed wheel, D, is free to rotate in one direction, but if you attempt to move it in the other the small rollers, marked E, roll up the inclined planes on that portion, B, of the

FIG. 22.—OTTO AND LANGEN LOOSE PISTON GAS-ENGINE.



clutch which is keyed to the shaft, and are jammed between the outside of this and the inside rim of the toothed wheel, the result

FIG 23.—OTTO AND LANGEN LOOSE PISTON ENGINE CLUTCH.



being that the attempt to revolve the toothed wheel in this direction grips the shaft, and causes it to travel with the wheel.

Let me ask you again to look at Fig. 22. You will see that towards the bottom of the cylinder there is a slide valve which admits the gaseous mixture, and through which—in a manner somewhat similar to that adopted by Hugon—the "firing" is done. Through this valve, also, the exhaust takes place. There is a pawl, worked by a ratchet wheel with a system of levers, by which the rack and the piston attached to it are lifted during the first portion of the upward stroke of the piston, while the charge of gaseous mixture is being drawn in preparatory to firing. The engine moving on still further, the pawl raises the slide valve; the light is applied to the gaseous mixture; this is fired, and the piston is driven upwards until the pressure beneath it falls below that of the atmosphere, in fact, until the energy produced by the combustion is absorbed in lifting the weight of the piston and rack, and in overcoming the pressure of the atmosphere above the piston, *i.e.*, until there is a partial vacuum formed in the cylinder below it.

When all this energy has been absorbed, the piston ceases its movement upwards, begins to return, being carried down not only by its own weight, but by the pressure of the atmosphere above it which is exerted over its whole area. As I have said, in going downwards, the rack attached to it engages with the toothed wheel, and the fly-wheel shaft is rotated by means of the clutch. The actual work in this engine — that of rotating the shaft—is therefore done in a most appropriate and convenient way. It is done on the down stroke by the atmospheric pressure on top of the piston, added to the weight of the falling piston.

Let me ask you to look at the indicator

FIG. 24.——OTTO AND LANGEN ENGINE. INDICATOR DIAGRAM.

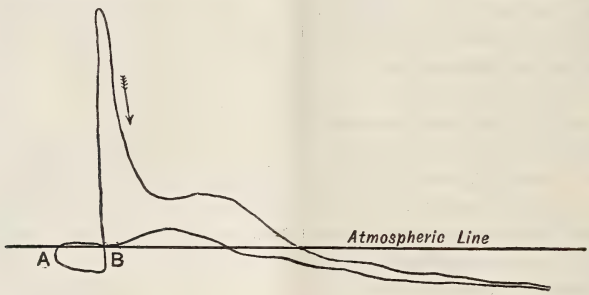


diagram (Fig. 24) of such an engine as this. This is not a diagram as actually produced, but one where the oscillations due to the weakness of the spring of the indicator have been to some extent eliminated.

Between the points, A and B, the piston is moving upwards, drawing the explosive mixture into the cylinder; and you will see the line is here a little below the atmospheric line. The firing then takes place, the pressure suddenly rises to about 60 lbs. on the square inch, falls almost as rapidly as the piston is driven upwards, and you will see that when the piston has travelled about 35 per cent. of the whole stroke, the pressure line falls to that of the atmosphere, and for the remainder of the stroke is below the atmospheric line—that is to say, there is a vacuum below the piston, which, when the piston has reached the top of its stroke, is equal to an atmospheric pressure of as much as 10 lbs. on the square inch, if I may put it in that unscientific but expressive way.

The piston now begins to fall, and begins, as I have said, to do the work of rotating the shaft, and the diagram of pressure below the piston follows the lower line, which, as you will see, does not reach the line of atmospheric pressure until the piston is within 25 per cent. of the end of the stroke, instead of at 35 per cent. from the bottom, as it was when the piston travelled up.

The reason for this requires a little consideration. If you will again look at the diagram of the engine you will see that the working cylinder is surrounded by a water jacket. This carries off some of the heat generated by the burning of the gaseous mixture, partially condenses the gases in the cylinder, and thus, lowering their temperature and pressure, helps to increase the vacuum below the piston; working on a practically similar principle to the condenser in a steam engine.

You will see that from the point where this line crosses the atmospheric line to the end of the stroke, owing to the exhaust valve

not opening quick enough, there is a rise in pressure above the atmospheric line; this means so much resistance to the movement of the piston, and therefore to the rotation of the shaft.

Let us now consider that further improvement made by the inventor of the Otto and Langen free-piston engine, which has rendered the gas engine the admirable apparatus for its purpose which it is.

This improvement consisted in so arranging the "cycle" of operations and the proportions of the length of the cylinder and the stroke of the piston that the gaseous mixture in the cylinder is compressed and stratified, that is to say, in the improved Otto engine (more commonly now known as the Crossley engine) there is, close to the piston when explosion takes place, a layer of the products of combustion from the previous stroke (these products of combustion being, as you will realise, incapable of themselves burning), and that then there is a layer of weak explosive mixture, and the charge gets stronger and stronger of gas, due to the arrangement of the air and gas inlet valves, till the back of the cylinder is reached, and here, where ignition takes place, the mixture is at its strongest.

Further than this, the arrangement of the "cycle" is such that the efficiency and economy of the engine are increased by the fact that, prior to explosion, the inlet valve has been closed, the stratified charge has been, so to say, bottled up in the cylinder, the piston has come backwards, and the stratified charge has been compressed so that, at the moment of combustion, it has a pressure of, say, 40 lbs. on the square inch.

This compression will, according to the second law governing the expansion of gases, give you, for an equal increment of heat, a pressure very much in excess of that which would arise if there were no compression; and the stratification will give you a charge of gaseous mixture which will readily ignite at that part where it is richest of gas, and will burn, not with explosion, but only with very, it may be with extremely, rapid burning, and where the power generated by combustion will thus be somewhat gradually applied to the piston, and through it to the crank shaft.

Having now stated to you, as shortly as possible, the advantages appertaining to this improvement, I will ask you to consider the "Otto" engine, which is, I suppose, to a greater extent the gas engine of the day than is any other. It is the engine in which stratification and compression were first made a thorough and practical success.

In order to understand this engine, I must deal again with the question of "cycles." If you will remember, in the Hugon and Lenoir engines there was, as in the steam engine, an impulse for each stroke of the piston, that is to say, two impulses per revolution of the crank shaft. Now, in the "Otto" engine we have only one impulse for each four strokes of the piston, that is to say, one impulse for each two complete revolutions of the crank shaft.

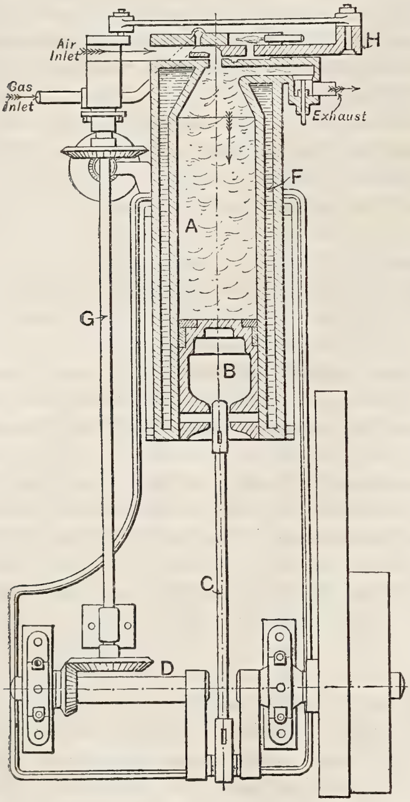
Let me ask you to look at this model, which shows, by the varying colours displayed in succession in the cylinder, the sequence of operations taking place there, or, in other words, gives you by the variation in these colours the "cycle" which occurs.

We will commence with the first "out stroke" of the piston. When this is taking place, the slide-valve admits the charge of gas and air—in the order already explained—this charge being drawn into the cylinder by the forward movement of the piston, the slide-valve then closes the ports, and on the first "in stroke" the piston compresses the charge into the space you will see at the back of the piston, between it and the cylinder cover. The charge is then ignited, the piston makes its second stroke outwards—this being the power stroke—and the motion being made because of the combustion of the gaseous mixture. Then the fly-wheel carries the piston again inwards, the second in-stroke is made, a portion of the burned gases being expelled through another port in the slide valve into the atmosphere. Our engine is now in the same condition as it was when we started, and the "cycle" is complete, for on the next forward movement the charge of gas and air will be drawn in. You will realise that the essence of this cycle is the compression and stratification, but you will also see that, ignition taking place only once in every two complete revolutions, a certain time is allowed, during which the water jacket will have time to cool the cylinder. I will return to this point of cooling of the cylinder again directly.

Let us now look at the diagram, and see what the engine itself is like. Fig. 25 (p. 742) shows you a plan section through the cylinder. You will see here the deep piston, marked B, to which one end of the connecting rod, C, is directly jointed; the cylinder being single-acting, and, therefore, open-ended, the other end of the connecting rod can take hold directly of the crank

on the crank shaft, D. On this crank shaft there is a bevel wheel, driving, by means of another bevel wheel at right angles, a longitudinal shaft, G, carrying at its extreme end, and at the back of the cylinder, the rod which works the slide valve. The exhaust valve, which is under the cylinder, is worked from this hori-

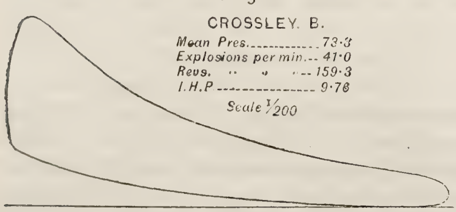
FIG. 25.—OTTO AND CROSSLEY GAS-ENGINE.



Plan.

zontal shaft by a cam and a rocking lever, not shown on the diagram. The outside appearance of the engine is, as most of you know, practically the same as that of a horizontal steam engine with a long cylinder.

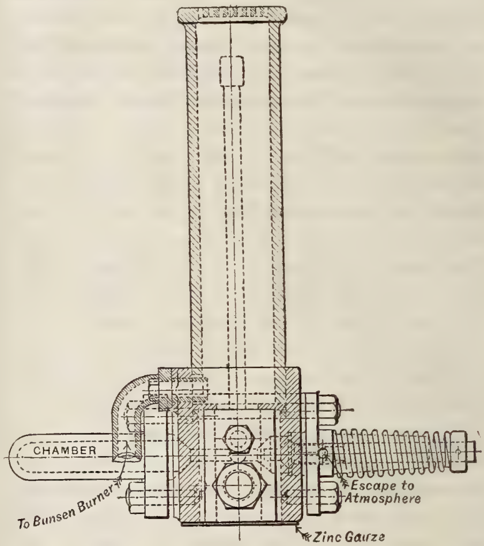
FIG. 25A.



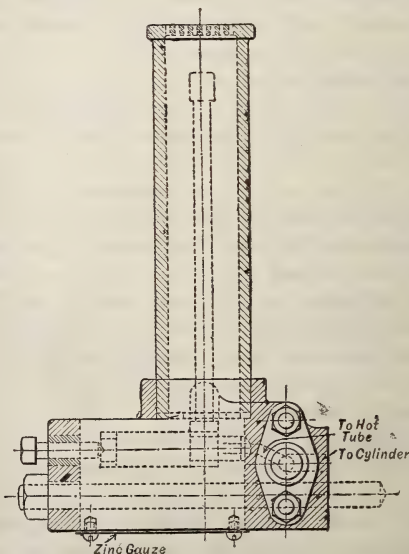
I have already shown you one of the indicator diagrams obtained from such an engine as this. Fig. 25A is another, and is one of those taken by the judges in the electric motor trials, to which I have had so frequently to refer.

The engine was of the usual "Crossley" type, having a working cylinder $9\frac{1}{2}$ inches diameter, with a stroke of 18 inches. The indicated horse-power at full load was 17·12, the brake horse-power was 14·74, and the ratio between brake horse-power and indi-

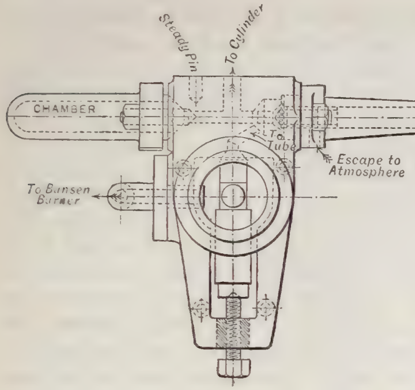
FIG 26.—CROSSLEY'S PATENT IGNITING BLOCK.



Front Elevation.



Side Elevation.



Plan.

cated horse-power was as 86 to 100. The gas consumed per indicated horse-power per hour in the cylinder was 20·55 cubic feet, that required for ignition being ·21, or about 1-5th of a cubic foot per hour extra. In the Crossley engines the ignition of the gaseous mixture has, until recently, been performed by direct flame ignition, in a manner somewhat similar to that which I have described as being in use in the Otto and Langen free piston engine; but Messrs. Crossley have now introduced a modification of a form of tube igniter, which needs some little description.

In this (see the three views of Fig. 26) there is a closed igniting tube, which is kept hot by a "Bunsen" flame burning externally to it. There is a valve which is opened and closed by means of a lever worked by the engine, and this valve opens communication between the igniting tube and the cylinder at the right moment, allowing a portion of the charge from the cylinder to pass into the red-hot tube, thus igniting the charge and causing the power stroke. The use of this mode of ignition does away with that constant source of trouble in the earlier engines, the slide valve.

I have here a model showing, in a similar manner to that of the model of the Crossley engine, the cycle of operations in the Clerk engine, which was at one time largely in use. You will see that in this case there is at the back of the cylinder a space of a conical shape to contain the compressed charge, and the unexpelled products of combustion, and that the gaseous mixture is compressed in a separate vessel or pump.

(To be continued.)

Miscellaneous.

GERMAN FLOATING EXHIBITION.

Consul-General Oppenheimer, of Frankfort-on-the-Main, in his report just issued says that the idea of establishing a floating commercial museum of German articles, recently planned by the Association for the Promotion of German Export, has met with general approbation in all industrial circles of Germany. A committee, consisting of the leading manufacturers of Germany, has been constituted to take the matter in hand, and hopes are entertained that the object contemplated will be accomplished. The prospectus points to the fact that exhibitions in their present form have outlived themselves. But in order to maintain the cultivation of international commercial intercourse, it would be necessary to replace the present system of international shows by a more advanced form, namely, to find the purchasers in their own country. For this purpose it is intended to construct a monster steamer fitted up with all modern improvements and conveniences. This steamer is to contain eight large show-rooms, provided with galleries for the reception of the articles to be exhibited. The goods are not to be placed in cases or boxes, but will be arranged in groups properly fastened in order to prevent their being injured by packing and unpacking, so that the exhibition, which is to visit eighty places, may be opened at once on entering at any of the ports. The staff, besides possessing commercial and technical knowledge, must be conversant with the principal modern languages. Like the continental exhibitions, which, in order to insure the success of the undertaking, must make it an object to attract the masses, the floating exhibition is to include entertainments of various kinds, taking on board not only persons sailing with a view to business, but also tourists. There will be concerts, theatres, &c. Restaurants and cafés will also be provided. A panoptical cabinet, a panorama, and similar shows will afford sightseers an opportunity of gratifying their curiosity, and souvenirs may be obtained at the photographer's studio and at the bazaars. The object to be attained by the above arrangements is not only to keep up the interest in the undertaking, but the benefit therefrom will enable the promoters to accommodate passengers and exhibitors on favourable terms. In addition, it is expected that the capital (£250,000) will yield a fair rate of interest, as, judging from estimates, the expenses of a voyage of about two years, calculated at £187.500, are met by gross receipts amounting to £393,650. Thus, the company hope to pay, after having made ample pro-

vision for redemption, an annual dividend of about 30 per cent. to the shareholders. As regards the dimensions of a steamer containing the above-mentioned eight large show rooms, concert rooms, restaurants, &c., intended to receive thousands of visitors, and to find accommodation for the crew, staff, and passengers, it is stated that this monster steamer, a floating palace bearing the name, *The Emperor William*, will be the largest vessel crossing the ocean. Her length is to be 570 feet by 70 feet, and her height 45 feet. The vessel will be constructed of steel, and will be propelled by four-fold compound engines. Ventilators, electric light, refrigerators to reduce the temperature in the hold and engine rooms, and other arrangements will likewise be introduced. The originators of the scheme think that it will be to the advantage of German industry that the Transatlantic purchasers should thus learn at once the origin of the goods, as they state that German merchandise, representing a value of many millions of marks, is regularly going to foreign markets by way of England, Holland, France, &c., without the consignees having, in most cases, the least idea as to its real origin.

PRODUCTION OF PERSIAN TOMBAK.

This narcotic, which is known under the name of *Nicotiana Persica*, is cultivated in Persia exclusively, in the provinces of Chiraz, Kechan, and Ispahan. Its quality varies with the place of production. The best tombak is that which is derived from Chiraz. The production of this province varies between 1,500 and 2,000 bales a year, which is almost entirely consumed by members of the Imperial family. The *Journal de la Chambre de Commerce de Constantinople* says that tombak of this superior quality is not very abundant, and the price paid for it is about fifty or sixty francs the oke, the oke being equivalent to 2·8 lbs. avoirdupois. The province of Kechan produces the second quality of Persian tombak. With small leaves like the Chiraz tombak, the product of Kechan is not even so abundant. The province of Ispahan is the centre of the product for exportation. Its cultivation is carried on on a large scale, and the plant, which has a large leaf, forms the third quality of Persian tombak. It has been vainly endeavoured to grow this plant in other localities of Persia and Turkey, and experiments which have been made in growing Chiraz tombak in the districts of Ispahan and Kechan have not been attended with successful results. This is attributed to the quality of the soil. Tombak, which is used in the same way as tobacco, is cultivated in a manner almost identical with that followed in tobacco cultivation. The seeds are sown in the month of May, and as soon as the young plants have attained a height of from fifteen to twenty centimetres they are watered once a fortnight. The harvest takes place in September or December, when the leaves are cut and spread upon the ground, where they are exposed to the dew for a period of forty-eight hours, and to this exposure they owe the fact of their being slightly stained with little black patches on the leaves. When carried to the warehouses the leaves are piled one upon the other. A slight smoking to which they are subjected in the warehouses gives to the leaves a greenish tint. The warehouses are then carefully closed so as to exclude all air, and at the expiration of a fortnight the leaves are sorted and packed. In the latter operation the following is the method employed:—After having separated the leaves one by one, they are placed one upon the other, and pressed in bundles of from forty to forty-two okes. They are then wrapped in pieces of American cloth, which are stretched and sewn up in the form of bales, called *torba*. These *torba*, which are covered with sheepskins, half dressed, are then ready for delivery to the trade. Tombak in good condition, packed in bales, and warehoused in places not too dry, may be kept without any deterioration for several years.

WINE PRODUCTION IN THE CANARY ISLANDS.

In the last report by M. J. B. Allarh, Belgian Consul at Santa Cruz., Teneriffe, upon the subject of vine cultivation in the Canary Islands, he calls attention to the possibility of acclimatising the Canary vines at the Congo, and in view of the success that has attended their cultivation in several tropical colonies, he predicts an excellent future for it in the Congo district. It was only five years ago that the first vine shoots were sent to New Caledonia, and the cultivation there was attended with such satisfactory results that a considerable quantity of wine was produced there last year. In March last 900 plants were sent to Guadeloupe, where similar consignments had produced excellent results. In the Canary Islands there are no vineyards, properly so-called, if the Monte Lantiscal be excepted, this consisting of poor land, a succession of hills and valleys, covered with volcanic cinders mixed with a little soil. In nearly all districts where the vine is cultivated it is planted in a single, or at most a double row, around fields devoted to the cultivation of potatoes and cereals. A vine often attains a length of from 10 to 12 metres, and only produces fruit in its last branches. Notwithstanding this, there is frequently a yield of 50 hectolitres to the hectare, and even more in certain privileged lands (hectolitre = 22 imperial gallons; hectare = 2·47 acres). Consul Allarh says that it would be difficult to say what would be the extent of the production of vineyards planted and cultivated in

a scientific manner in the cultivable districts of the Grand Canaries or Teneriffe, but it would no doubt be very considerable. The principal descriptions of grapes are for making dry Madeira and Teneriffe wine, the Vigariego, which is also known as the black Listan or Vidueno. This is the old Spanish grape which was first introduced into the islands, and produces an excellent wine; it is of medium size, and dark in colour. The Tintillo is another description; this is the Pineau of Burgundy, which was imported about two or three centuries ago. It gives a highly-coloured wine, with good flavour and bouquet. The sweet Negro furnishes a wine inferior in quality to the Listan, but it possesses a good flavour. For making white wines, the Malmsey has made the reputation of the Canary Islands. It is, however, very rarely that this grape is met with, and is only to be found in a few localities. Its wonderful bouquet and well-known qualities are so established that it would again, says M. Allarh, find many markets if the cultivation of the vine was only scientifically practised in the Canary Islands. The white Vidueno is an old Spanish description of grape, furnishing a fine and well-flavoured wine, if only the proper time is chosen for the vintage. Formerly, the must of the Malmsey was mixed with that of the white Vidueno. The Verdello, a small oblong grape, and the Marmajuelo, which is very little cultivated, yield excellent wines, while the Forastera, both red and yellow, are very carefully cultivated by some vineyard proprietors and comparatively neglected by others. It is from the latter that a dry sherry is made. The white Muscatel makes a sweet and highly appreciated wine. The preparation of ordinary land in the Canaries for vine growing is somewhat costly. After having chosen a black sandy soil, the farmer makes his plantation in the months of January or February, by cutting a trench about eight feet wide and three feet deep. The vines, planted at a distance of about one *vara* (three feet), are then covered with earth. During the first year six operations are necessary to keep the ground in condition. The second year after planting the ground is again turned over, and any leaves that may have sprouted are removed from the vine, nothing being allowed to remain above the level of the ground but the bare trunk. It is only in the fourth year that the vines begin to bear grapes, while it is only after the fifth that a good yield is obtained. The time of harvest varies according to the land. In certain districts it commences about the 20th of September, while in others it is not over until the beginning of November. As regards the cost of cultivation, a hectare of average land is valued at £80, while the expenses of preparing it for vine cultivation, according to the composition of the soil, amount to from £40 to £45, making a total of £125, to which should be added the interest on the capital sunk until the harvest time, that is for four years, at the rate of 7 per cent., which would be about £33, including taxes and wages. The cost, therefore, per hectare under vine cultivation would amount to £158. The cost of cultivation varies very much with the position of the vineyard. Those on high lands, on the old lava or volcanic soil, are the most expensive, as they produce a superior quality of wine to those situated towards the south. As regards the yield of wine, it may be taken on an average at about eight or ten pipes to the hectare, and the average value of the pipe is about £6. That is from £48 to £60 per hectare. Out of this must be deducted 50 per cent. for interest and repayment of capital, wages, and taxes, thus leaving a net revenue varying between £24 and £30 annually. Certain vineyards, exceptionally well situated, yield up to fourteen and sixteen pipes of wine, which sell in the month of January at about £10 the pipe; the value of these vineyards is over £400 the hectare. There are no taxes in the Canary Islands on the import or export of wine, and no octroi duties are levied.

BUHACH.

Buhach, the name given to a Californian product, is a fine powder made from the flowers of the *Pyrethrum cinerariæfolium*, largely used for destruction of insects. This plant was originally a native of Persia, from whence it was introduced to Dalmatia and adjoining States of Herzegovina and Montenegro, where it has been almost exclusively cultivated until a few years ago. The importance of this industry was considered so great in these countries that special efforts were made to prevent the export of seeds and plants by the Governments. The plant was first introduced into California about twelve years ago by a Mr. Mileo, a native of Dalmatia, who succeeded, after some trouble, in obtaining seed from his country. After experimenting for sometime, in order to find a suitable soil and climate, this gentleman finally succeeded in growing the plant on an extensive scale, and in 1880, associating himself with other capitalists, established the Buhach Producing and Manufacturing Company. At the present time the company have about 300 acres of this plant under cultivation at their farm near Atwater, Merced County, California, and own mills for grinding the dried flowers to powder at Stockton, near San Francisco. The cultivation of the *Pyrethrum* requires careful and intelligent supervision, and it cannot be grown successfully without irrigation. It requires three years from the time of sowing to grow plants capable of producing a paying crop of flowers, and then they will bear from four to five years longer. It is at its prime, however, in its fourth or fifth year. The plant grows about 30 inches high, and is set out in rows 4 feet apart, and from 15 to 24 inches apart in the rows. The flowers are harvested towards the latter part of May. The stalks are cut just above the roots, and

the flowers stripped from them by passing the plants through a kind of comb. The detached flowers fall into a box below, and are carried to the drying ground, where they are spread on sheets and exposed to the rays of the sun during the day, being repeatedly turned over in the meanwhile. They are covered during the night to prevent their absorbing moisture, as the perfect drying of the flowers is most important in order to retain the volatile oil which gives the powder its insecticide properties. It is also very necessary that this operation should be done quickly, and that the flowers during the drying process should be protected from moisture. A slight dew falling upon the flowers at this time will injure their colour, and reduce their strength as an insect destroyer. In this respect the California-grown flowers are better cured, and, consequently, more valuable than those produced in Dalmatia, it being acknowledged by experts that the particular conditions of soil and climate in California are extremely favourable to the growth and curing of plants, rich in the essential oil which renders them so destructive to insect life. Like many other products, insect powders are liable to adulteration, and last year a large quantity made from the flowers of the Hungarian daisy, mixed with a small proportion of pyrethrum, was placed upon the market by unscrupulous dealers. Inferior powders are also manufactured from the stems and leaves of the plant, which possess, to a certain extent, the properties of Buhach.

SAWING STONE BY HELICOIDAL WIRE-CORD.

In place of the ordinary method of sawing stone, a new plan of cutting by means of wire-cord has been adopted. While retaining sand as the cutting agent, M. Panlin Gay, of Marseilles, has succeeded in applying it by mechanical means, and as continuously as the sand blast and band-saw, with both of which appliances his system—that of the "helicoidal wire-cord"—has considerable analogy.

An engine puts in motion a continuous wire-cord (varying from $\frac{5}{32}$ to $\frac{7}{32}$ of an inch in diameter, according to the work), composed of three mild steel wires twisted at a certain pitch, that found to give the best results in practice, at a speed of 15 to 17 feet per second, the higher speed being adopted for the smaller diameter.

Instead of the stone being brought to the saw, the wire-cord, which may be of indefinite length, is led to the stone, being guided by grooved pulleys, mounted on bearings with universal joint, which permits of their adapting themselves to any change of direction. The same cord, which is kept at uniform tension by a weighted truck on an inclined plane, may act upon any number of blocks, provided sufficient space be given between them to allow for cooling.

The pulleys are mounted in standards, and are fed down by endless screws rotated automatically if the stone be uniform, but preferably by hand if there is reason to suspect irregularities in its texture. Sand and water is allowed to flow freely into the cuts, the sand carried along by the cord in the spiral interstices between the wires causing a uniform attrition of the stone. The twist of the cord causes it, while travelling, to turn upon itself, and thus become worn evenly. A cord of average length, say 150 yards, will cut about 70 feet deep in blocks 15 feet long, or produce 490 square feet of sawn surface before being worn out, when it may be used for fencing.

The sand must be sharp, and not used more than three times. The nature of the sand is determined by the hardness of the stone; thus, quartz sand will cut granite and porphyry, which it has hitherto been found impossible to saw, or indeed cut in any other way than by pick or chisel. An hourly advance of 1 inch in granite or porphyry, and 4 inches in marble is regularly obtained in blocks of 15 or 16 feet long. At the Brussels Exhibition of last year, where the system was awarded a First Prize of Progress, the same cord which cut marble also cut a block of concrete composed of quartz pebbles.

Not merely does the helicoidal cord saw blocks of stone, but it even cuts them out of the solid rock in the quarry. To do this, it is necessary to sink shafts of 2 ft. or 2 ft. 6 in. in diameter, in order to introduce the pulley carriers. If there is a free side to start from, one shaft is sufficient for a triangular block; but for a quadrangular one, which is preferable, two shafts are necessary. They are bored by a mechanical perforator, consisting of a hollow-plate iron cylinder, having at its lower end a slightly thicker collar which acts with sand and water in its latest development. The cylinder is made to revolve, at a speed of 140 revolutions a minute, by means of a tele-dynamic cable, advancing about an inch per hour in marble. An annular space is cut in the rock, leaving a core, which may be utilised as a column. The diameter of the shaftway depends upon the diameter of columns most in demand, provided a sufficient number be sunk, and the intervening angles broken down, so as to afford sufficient room for the pulley carrier.

In the case of stratified rocks, the shaft-cuts are carried down to a natural parting; but in unstratified rocks a nearly horizontal cut may be made with the cord, sufficient inclination being given to insure the flow of sand and water to the bottom of the cut.

Such is the method of working practised at the Traigneaux Quarry, near Philippeville, in Belgium, where 15,000 cubic feet of marble are extracted yearly with a 30 horse-power engine, and only 30 hands in summer and 20 in winter, besides the lads who tend the wire-cords. The system is also employed at granite and marble quarries in France, Germany, Spain, Italy, Algeria, Tunis, and other countries, where it is said to be giving satisfactory and economical results.

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FRIDAY, AUGUST 16, 1889.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

ART-WORKMANSHIP PRIZES.

The Society of Arts offer the sum of £150 in money prizes, as well as twenty of the Society's Bronze Medals, for objects in the Arts and Crafts Exhibition to be held in the autumn of the present year. The judges will be empowered to distribute the money, or such proportion of it as they see fit, in any sums they think will best meet the relative merits of the exhibits, at the same time paying due regard to the cost of production. The whole sum will only be expended in case of works of sufficient merit being forthcoming.

It will be understood that the Arts and Crafts Exhibition Society do not undertake responsibility in respect of the awards of the prizes, which will be a matter solely under the control of the Society of Arts.

The following rules under which the prizes will be offered are substantially the same as those under which the previous art-workmanship competitions of the Society have been carried out.

The prizes will be awarded to craftsmen, not professional artists, and the work must have been executed in the United Kingdom or its dependencies.

The objects submitted for competition may be the work of one workman, or of several workmen working in combination. They need not necessarily be the property of the workman or men sending them in. Manufacturers or employers may exhibit articles on behalf of their workmen. In this case, besides the name of the manufacturer, the names must be given of all the workmen who have executed portions of the work, with a statement of the portion executed by each. If any prizes are awarded they will be given to the workmen.

In awarding the prizes, the judges will take into account the following points:—

1. Originality or beauty of design.
2. Fitness of treatment.
3. Excellence of workmanship.

The works will remain the property of the competitor or of the person from whom he has borrowed them for the competition.

All the prizes are open to male and female competitors on equal terms.

The Exhibition of the Arts and Crafts Exhibition Society will open at the New Gallery, Regent-street, on Monday, October 7th, and will close on December 7th.

The following is the classification of the objects to be received for exhibition, as put forth by the Arts and Crafts Society:—

(a) Designs and cartoons for decoration of all kinds.

(b) Decorative painting—more particularly in association with architecture or cabinet work.

(c) Textiles—Tapestry, Needlework, woven and printed patterned Fabrics, Lace.

(d) Painted glass.

(e) Pottery—Tiles, Majolica, painted China.

(f) Table glass.

(g) Metal work—Wrought iron, brass and copper Repoussé, Gold and Silversmith's work and Chasing.

(h) Wood-carving } Carving in ivory and
(i) Stone-carving } other materials.

(j) Cabinet work—inlaid, and painted and carved furniture.

(k) Decorative Sculpture and Modelled Work—Friezes, architectural enrichments, relievos, plaster and gesso work, &c.

(l) Printing—Book decoration, Printers' ornaments, Illuminations and decorative MSS. Wood and metal engraving.

(m) Book-binding and cloth-cases.

(n) Wall papers.

(o) Stencilling.

(p) Leather work—Stamped, tooled, cuir-bouilli, &c.

And such other kinds of decorative Art not above enumerated as may be approved by the Selection Committee.

Information respecting the Exhibition and

forms of application may be obtained from Mr. Ernest Radford, Secretary of the Arts and Crafts Exhibition Society, at the office, 44, Great Marlborough-street, London, W.

H. TRUEMAN WOOD,
Secretary.

Proceedings of the Society.

CANTOR LECTURES.

HEAT ENGINES OTHER THAN STEAM.

BY H. GRAHAM HARRIS, M.Inst.C.E.

Lecture III.—Delivered May 20th, 1889.

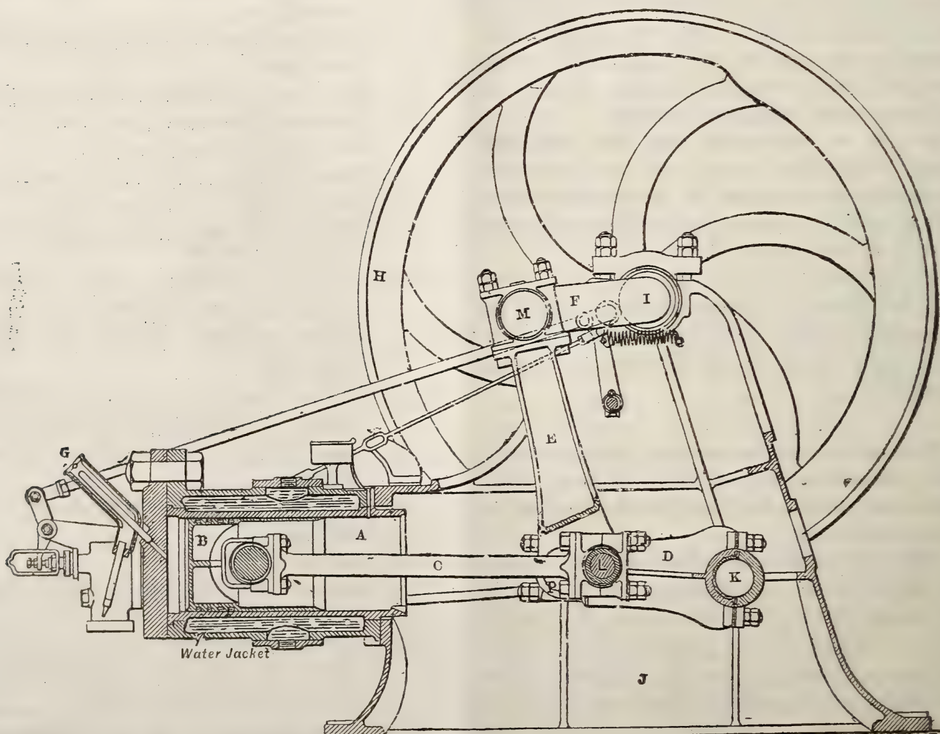
(Continued from p. 743.)

The next engine to which I have to call your attention (the "Atkinson") is one which, in appearance at least, is very different from any other. I think, perhaps, I had better first describe to you the engine as it now exists, and then occupy your time for two or three minutes while I relate to you the phases of development through which it has passed.

You will have realised from the description of the Crossley and of the Clerk engine that, among the peculiarities of these engines is the fact that an impulse to the crank is so infrequently given. By means of the linked-rod arrangement of the Atkinson gas engine (see Fig. 27) there are, for each revolution of the crank shaft, four strokes of the piston, this allowing (while maintaining a similar "cycle" to that of the Crossley and Clerk) of one impulse to the crank for each revolution; the arrangement is such also that each four strokes, two out and two in, are of unequal length, and it is only when these four strokes are completed, *i.e.*, at the completion of each revolution, that the "cycle" is complete.

Let us look at the cardboard model I have here, and let me place the piston in the position which it occupies at the commencement of the first "out" stroke, *i.e.*, in that position when its next movement will be outwards, and when it will draw in its charge of gaseous mixture. I make the stroke, and you will see that the crank shaft has travelled through about 68° out of the 360° which make up the com-

FIG. 27.—ATKINSON'S CYCLE GAS-ENGINE.



plete revolution. The next 66° (about) of movement of the crank shaft causes the piston to make the first "in" stroke, this being the compression stroke, when the charge of gaseous mixture is compressed. The lengths of the levers are such that while the "out" stroke (the suction stroke) was, say, $6\frac{1}{4}$ inches, this "in" stroke (the compression stroke) is only 5 inches, *i.e.*, there is a space left at the back of the piston, between it and the cylinder cover, into which the charge has been compressed.

Let us now move the crank shaft further onwards, for about 98 degrees, and you will see that the piston again moves outwards, this being the explosive stroke, and it moves outwards for as much as $11\frac{1}{4}$ inches; the further 128 degrees of movement of the crank shaft (the movement sufficient to complete the revolution) causes the second "in" stroke to be made, when the products of combustion are expelled, and this stroke moves the piston inwards for $12\frac{1}{2}$ inches, and brings it to that position which it occupied at the commencement of the "cycle." The lengths of the successive strokes are:—

No. 1	.. Out stroke (suction)	$6\frac{1}{4}$	inch.
No. 2	.. In stroke (compression) ..	5	,,
No. 3	.. Out stroke (combustion) ..	$11\frac{1}{4}$	,,
No. 4	.. In stroke (expulsion)	$12\frac{1}{2}$	,,

You will easily realise that, in addition to the advantage obtained by the greater regularity of turning effort upon the crank shaft, such an arrangement as this, which will give proper, defined, and varying lengths of movement of the piston is commendable.

There is no doubt that the fact of the charge of gaseous mixture being exposed only to the heat of a portion of the cylinder, instead of to its whole length before being ignited, is advantageous.

In the Atkinson engine used in the motor trials the cylinder was $9\frac{1}{2}$ inches diameter, and the radius of the crank of the engine was $12\frac{7}{8}$ inches. The arrangement of linked rods, by which the succession of movements of the piston is obtained for each revolution, will be understood best from the cardboard model which I have been working.

You will see from Fig. 27 that, as in the Crossley engine, the cylinder, A, is single-acting and open-ended; that the piston, D, is sufficiently long to form its own guide in the cylinder that one end of the connecting-rod, C, is attracted directly to it; the other end being attached to the toggle joint of this pair of levers, D, E. The other end of one of these levers is attached to the crank, F, on the crank shaft, I, and the other end of the second lever is anchored to the engine frame at K. The variation in the lengths of the strokes of the piston is obtained by jointing the outer end of the connecting rod, not precisely to the centre of the toggle joint, but to a point, L, on the anchored lever nearer to the centre of the anchorage.

The ignition in this engine is performed by an igniting tube somewhat similar to that employed in the Crossley engine, but in this case there is no valve for opening communication from the igniting tube to the combustible charge, the moment of ignition being determined by the position of the tube.

There are several other practical points in connection with this engine, which compel me to linger a little longer about it, although our time is passing very rapidly.

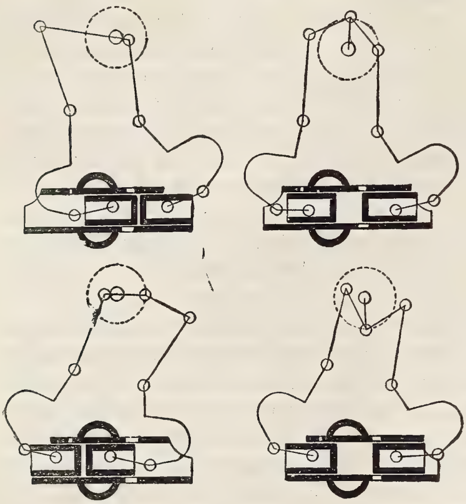
The Atkinson construction of engine, as you will see, lends itself to simplicity of arrangement. At first it seems that a large proportion of the power which is developed in the engine, must, of necessity, be absorbed by the friction of the working of these linked rods; but when we compare the performances of the engine with, say, the Crossley, we find that in the motor trials, at full load, the indicated horse-power was 11·15, the brake horse-power 9·48, and that the ratio of brake horse-power to indicated horse-power was, therefore, ·850, as against the Crossley engine ·861; while the gas consumed in the Atkinson engine per indicated horse-power per hour was, as a total, 19·22 cubic feet, the Crossley, as you will remember, being 20·76; the difference between the two engines being in these respects very slight, although the Atkinson engine was somewhat the smaller.

We shall find that in the third of the modern gas engines over which we must spend some few minutes directly, the efficiency—*i.e.*, the ratio of brake horse-power to indicated horse-power—is not quite so satisfactory, nor is the gas consumption quite so low; but it is almost certain, in practical day-to-day working, neither one of these three engines has much economical advantage over the other.

The Atkinson gas engine, as it now exists, is very unlike the one first introduced by this firm. The original engine was called the "Differential" gas engine; as you know, the one we have just been considering is called the "Cycle" gas engine.

In the differential engine (see diagram No. 28) there was a somewhat similar peculiar arrangement of toggle-jointed levers, and these were worked by two pistons, which approached and receded from each other in a horizontal cylinder placed towards the bottom of the engine. The diagram (Fig. 28) shows

Fig. 28.—Atkinson's Differential Gas-engine.



the levers and pistons in four positions throughout the revolution of the crank shaft.

The principal advantage claimed for this engine was that the whole operations of admission, compression, ignition, expansion, and discharge are performed in this single cylinder by the aid of two automatic valves, which are never exposed to the pressure of explosion, the pistons themselves being made to act also as valves, uncovering the inlet, igniting, and exhaust ports when required. The engine, however, in spite of this, was not so simple and economical as the "Cycle" engine, the later and more improved type.

The other modern engine experimented with at the motor trials which I must describe is the engine known as the "Griffin" engine (see the two views of Fig. 29, p. 751).

It is a double-acting engine which, when working with full load upon it, ignites a charge of gaseous mixture at each end of the cylinder at every third stroke; that is to say, at every one and half revolutions of the flywheel there is an impulse first in one direction, and then in the other.

The "cycle" for each end is as follows:—The piston moves outwards, drawing in the charge of gas and air; it returns, compressing the mixture; this is ignited, and combustion takes place; the piston then moves outward under the pressure, it then returns, ejecting the products of combustion; it goes out again, drawing in a "scavenger" charge, as it is called, of atmospheric air, thus cooling the cylinder and diluting any products of combus-then left behind from the previous charge; it tion returns, ejecting the "scavenger" charge.

The operation at the other end of the cylinder follows the same sequence.

The engine, in general arrangement, is practically similar to an ordinary horizontal steam engine, or to the Lenoir or the Hugon gas engines, having the exhaust valves on one side and the gas and air inlet valves on the other. These valves are lift valves, however, and not slide valves. The ignition of the explosive mixture is, in this engine, a direct flame ignition, somewhat similar in principle to that of Barnett, already described.

The working cylinder of the engine tried by the judges in the motor trials, was a little over nine inches in diameter, the stroke being fourteen inches. The indicated horse-power was 15·47, the brake horse-power 12·51; the ratio of brake horse-power to indicated horse-power was nearly 81 per cent., and the total quantity of gas consumed per indicated horse-power per hour was about 23 cubic feet.

You will see that in all the modern gas engines which I have described there is compression of the mixture immediately prior to ignition, and you will realise that when it is necessary to start the engine, unless some special means are provided, the putting of the engine into the condition of having drawn in its charge of gaseous mixture, and of having compressed it, can only be done by turning the engine rapidly by manual power.

The necessity for this turning has, to a very large extent, limited the development of the gas engine for large powers. Messrs. Crossley, pioneers as they are in every improvement in connection with the gas engine, some years since devised an apparatus consisting of a small cylinder or reservoir, generally placed below the working cylinder of the gas engine, which can, at will, have a communication opened from it to the main cylinder behind the piston. Into this small reservoir, when the engine is working, air or products of combustion under pressure are delivered, these forming a store of power to be used when it is desired to start the main engine into motion.

This device has not been very largely

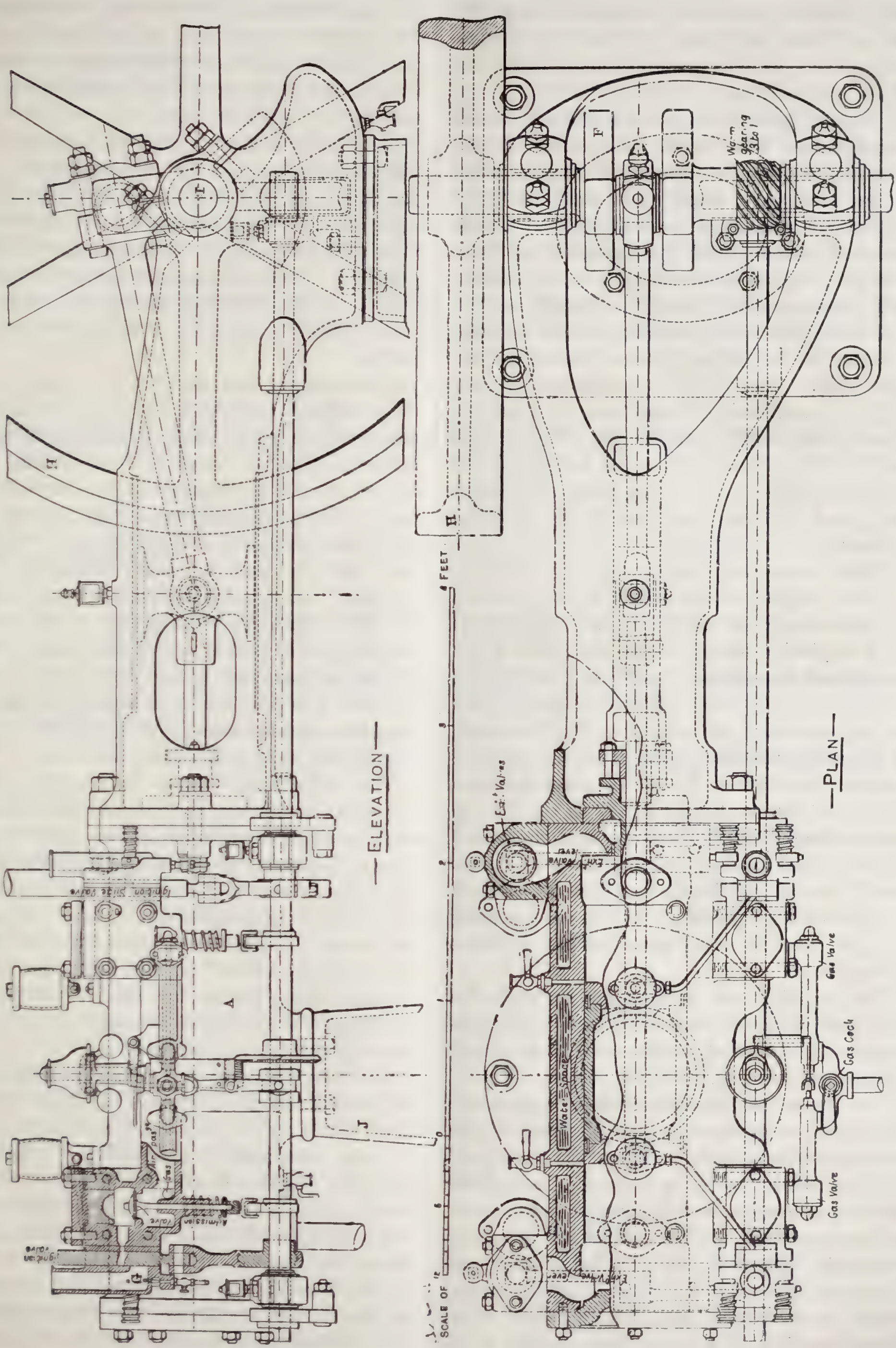


FIG 28.—GRIFFIN'S GAS ENGINE. (DICK, KERR AND CO)

adopted, and the starting difficulty still remains one which requires time and experiment before its satisfactory solution will be attained. That it will be overcome, and soon, is certain, for, as I have said, there are many able men who are day by day seeking for improvement in the gas engine.

I have purposely omitted (in order to avoid complication) from all the descriptions of gas engines which I have given you, any mention of the modes by which the speed of these engines is regulated or governed. These modes of governing vary in the details of their arrangement, but all the more recent are practically based on the principle of cutting out an explosion when the speed exceeds the normal. This is done by having a valve controlling the gas inlet. This valve is operated by the governor, and being closed when the normal speed is exceeded, prevents the admission of gas to the cylinder, the valve being opened and admission again taking place only when the speed has been reduced by the required amount.

Other devices have been suggested, having for their object the lessening of the quantity of gas allowed to pass into the cylinder at each explosive stroke while maintaining the quantity of air constant, in this way weakening or diluting the mixture when the speed of the engine exceeded the normal. But this mode of governing has been found to be very unsatisfactory, for at times the mixture would be too weak, and at other times would be too rich, in gas, and in either of these cases it would not "fire" in the cylinder, but the unburnt charge would be expelled from the engine at the next in-stroke of the piston, thus not only wasting the gas, but rendering some serious accident probable.

The principle of cutting out an explosion therefore, when the normal speed of the gas engine is exceeded, is the one now almost universally adopted.

Let us see the economical advantages which this mode of governing gives the gas engine over the steam engine. By it the fuel (gas) from which the power is obtained is supplied to the gas engine automatically, and in exact accordance with the necessities of the work which the engine is doing; that is to say, as the work varies, so does the quantity of fuel which is consumed vary; the number of explosive strokes in a given time varying automatically, and without attention by the driver.

You will realise therefore that this necessity (if I may so put it) of the construction and working of the gas engine gives it, from an economical point of view, a vast advantage over the steam engine; for in this latter engine an equal advantage could only be obtained if the governor regulated automatically, without the intervention of the driver or the stoker, and, as the work varied, the quantity of coal put into the boiler furnace.

Broadly speaking, it may be said that, in practice, the amount of fuel consumed in a gas engine is always proportional to the work being done by the engine, no matter how that work may vary; while in the steam engine, in practice, the fuel consumed depends almost entirely on the stoker or driver, and does not automatically vary as the work on the engine varies.

I have shown and described to you three of the principal distinctive forms of gas engine commonly in use. Each of these performs a different cycle of operations in turning the heat developed in the cylinder into mechanical work. The "Crossley" gives an impulse for every two complete revolutions, the "Atkinson" an impulse for each revolution, the "Griffin" an impulse for each $1\frac{1}{2}$ revolutions. In the "Crossley" and the "Atkinson" engines the impulses are always given while the piston is moving in one direction. In the "Griffin" engine, which is double-acting, the impulses are alternately with the piston moving first in one, then in the other direction.

You will see on Fig. 30 (p. 753) the turning effort on the crank shaft characteristic of each of these engines is shown graphically. These diagrams, which are taken from those given by Professor Kennedy in his paper on the motor trials, represent, by the height of the curved line above the horizontal base line, the "turning effort" exerted upon the crank shaft at every portion of each revolution of that shaft, the vertical dividing lines representing complete revolutions.

You will see that the steam engine, with two cylinders and with cranks at right angles, gives you a regular rise and fall of curve twice in each revolution; and without labouring this any further, I will just point out that among the gas engines, as you would expect, the "Atkinson" has, when the work it is doing does not vary, the most regular turning effort. For some purposes, especially for those of electric lighting, there is no doubt that this is an advantage thoroughly well worth having.

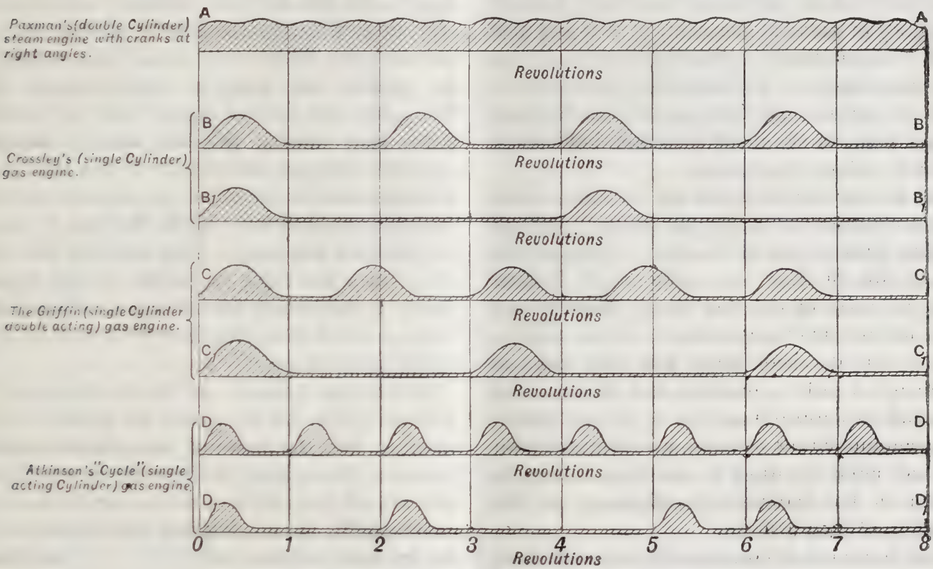
In addition to these engines which I have described, there are many other gas engines, such as the "Beck," the "Stockport," and

others, all of them having certain advantages and certain disadvantages; but as I have given you, in pretty full detail, a description of the three principal gas engines of the present day, I do not think it is necessary for our purpose we should occupy further time in discussing these other forms of gas engine.

Let us now consider what is the theoretical efficiency to be obtained from a gas engine; that is to say, let us endeavour to see what would be the efficiency of an ideal engine according to the doctrine of Carnot, where the working agent was at the temperature developed by the combustion of the gaseous mixture at the commencement of the cycle, and where, when the working agent was exhausted from the engine, its temperature had been reduced to something slightly in excess of that of the atmosphere. Assuming, as we must for an ideal engine, that all the heat represented by this difference of temperature is turned into mechanical work.

Mr. Dugald Clerk, to whose book I have already referred, made a series of most important and elaborate experiments on the heats and pressures of various strengths of mixtures, of atmospheric air and Oldham coal gas. These mixtures consisted of 1 volume of gas and 14 of air, 1 of gas and 13 of air, and so on, down to 1 volume of gas and 4 volumes of air. He burnt these mixtures in a closed vessel, with the result that (calculating the

Fig. 30.—Turning Effort on Crank Shaft.



temperature obtained from the observed pressure) he found the temperature ranged from, say, 1,600° absolute to nearly 4,000° absolute, depending on the amount of gas in the mixture, *i.e.*, upon its richness in gas. He also found that the more he diluted the mixture the lower was the maximum temperature.

Further, he found, on trying experiments with a mixture compressed before combustion, that the temperatures which are reached, or the pressures which are produced from any given mixture, are proportional to the pressure initially given to the mixture by compression.

This is what we should expect to find as the practical result, when we remember the two laws governing the expansion of gases, which we considered in the last lecture.

Let us assume, however, that which is generally taken to be true, viz., that the initial temperature of explosion in a gas engine is, practically, somewhere about 3,500° above absolute zero. The efficiency, according to the Carnot theory, of an ideal engine such as I have suggested above would be represented by

$$\frac{\text{Initial absolute temperature} - \text{Final absolute temperature}}{\text{Initial absolute temperature}}$$

Or stated in figures—

$$\frac{3{,}500^\circ - 530^\circ}{3{,}500^\circ} = \text{(roughly) } 84\tfrac{1}{2} \text{ per cent.}$$

Remember that, as I told you in the first lecture, the Carnot efficiency is an impossible

efficiency in any engine, because among other reasons it is impossible to construct an engine which shall not demand for itself and to keep it in motion some portion of the power obtained; because we know of no materials of which to construct our cylinders which will not absorb and dissipate some of the heat developed; and because, in practice, it would not pay to have an engine so bulky, and with cylinders so large as to allow of our expanding the working agent to such an extent as to allow it to pass from the engine at the temperature of the atmosphere, which is the temperature of exhaust we have in this case assumed.

As compared with this $84\frac{1}{2}$ per cent., which is the ideal theoretical efficiency under the above impossible conditions, we find that the engines tried at the motor trials only had an efficiency of some 26 per cent. of this $84\frac{1}{2}$ per cent. The mechanical efficiency, as you know, was stated to be 22 per cent., but this is 22 per cent. of the heat put into the engine, and not 22 per cent. of the ideal theoretical efficiency under the above conditions.

Let us now examine into the question of the losses which occur in the gas engine; each of the two great heads of loss being represented, practically, by this blue cube which I have here, the total of the two being about 75 per cent. of the total heat units put into the engine.

You will see how large this blue cube is (although it only represents a little less than one-half the total loss, that is to say, one of the principal heads of loss), as compared with the red cube we used in our first lecture to represent the mechanical efficiency, or the quantity of heat utilised.

The first head of loss with which we will deal, is that due to the heat rejected in the jacket water.

I think if we try and realise what are the practical necessities which compel us (if I may so put it), to bear this loss, we shall be the better able to understand the possibilities there are of eliminating or reducing it in the near future.

I have told you that the temperature of combustion which is attained in the gas engine cylinder, may be taken as equal to about 3,500° Fahr. absolute, and I have referred you to the experiments of Mr. Clerk, and should also like, upon this point, to again refer you to the records of the motor trials.

Now the melting point of cast iron may be taken as about 2,500° Fahr. absolute. Most of you know that the cylinders of a gas engine are composed of cast iron, and you may ask me why, if these temperatures are correct, the cylinders do not melt. Well, it is because of the jacket, and of the cooling water, which keeps the internal surface of the cylinder sufficiently cool to allow of lubrication.

I should like to relate to you a shop incident, as a practical illustration of a similar cooling effect produced by a liquid, an incident of which I have been told. A manufacturer had to make a pan or vessel in which a certain liquor was to be boiled. It was determined to make this vessel of tin, this metal not being affected by the peculiar liquor to be boiled in it, and wishing to provide a vessel which would last some little time, the manufacturer made it three inches thick. The vessel was completed, it was filled with the liquor, and the fire put under it; and after a very little time, to the horror of the manufacturer, he found the metal was melting, the molten tin running away through the fire. He got into a great state of excitement, and wanted the fire drawn; whereupon his foreman said to him, "No, sir, leave it alone, and the fire will very soon tell us how thick we ought to have made the pan." And the foreman was right. The fact was that the vessel was too thick to allow of the liquor which it contained absorbing or dispersing in the needed time the heat imparted to the vessel by the fire.

So with the cylinder of the gas engine. It is a necessity, as these are at present constructed, that the metal of the cylinder should be made thin enough to allow the jacket water to carry off the surplus heat as rapidly as it is generated by the combustion, and thus to keep the internal surface sufficiently cool to allow of efficient lubrication.

If you will remember I told you that Hugon, in his engine, had suggested the injection of a water spray for the purposes of lubrication, and a spray has also been suggested as a means of keeping down the temperature; but you will, of course, see that if a water spray were to be used in this way it would be a most wasteful means to adopt, because of the large portion of the heat of combustion which would be lost, becoming latent in vapourising the water of the spray into steam.

You will remember I said that air was an extremely bad conductor of heat; one result of this is that in the gas engine cylinder only the film of air which is in contact with the sides of the cylinder and with the piston communicates its heat to the cylinder, or is cooled, and the

cooling effects do not extend appreciably away from these surfaces. This want of conductive power of air, which we found was a disadvantage in those hot-air engines where the heat is communicated by contact with hot metal or other surfaces is, therefore, in practice, of advantage in the gas engine.

Lubrication, at the temperatures of which I have told you, would be impossible, if it were not for the water jacket, and for this quality of air. If any of you have examined the cylinder of a gas engine, you will find it is frequently as clean, and sometimes as bright as that of a steam engine, proving, therefore, that the lubrication in these machines is, as a rule, sufficient.

The water of the jacket, however, is not, as a fact, the only means by which cooling is done. The "cycle" of operations in a gas engine is such that an appreciable interval is allowed between the time of explosion and the time when the fresh charge of mixture is drawn in, and invariably during this time the piston has passed over the internal surface of the cylinder, thus helping to cool it, and the incoming cool charge of gaseous mixture has itself assisted in this, even in those engines where there is not a "scavenger" charge.

If it were not for these methods of cooling, it would, for a further reason than any which I have at present stated, be impossible to satisfactorily work a gas engine. Pre-ignitions of the explosive mixture would take place before compression could be effected, due to the heat of the cylinder walls, as well as to the heat generated by the compression itself, and these pre-ignitions would be irregular in their action, might occur even before the mixture had been compressed, or would almost certainly occur as compression was taking place, that is to say, as the piston was coming back, or, in opposition to its motion.

Many suggestions have been made that the cylinder should be composed of, or should be lined with, some substance which was non-absorbent, or opaque to heat, but as it is impossible to find any substance absolutely opaque, and as any substance which to any extent absorbs the heat would—unless its internal surface were cooled in some way or another—allow of, or even induce pre-ignitions, it does not seem to me that great improvement in this direction is likely to be attained, unless the internal surface of the cylinder is cooled by some means, say by a charge of cool air passing as a "film" over this surface.

The second great head of loss, which is practically equal to that of the loss by the jacket water, is due to the heat passing away in the exhaust.

You will remember I have just told you that in the ideal (Carnot) gas engine the greatest efficiency would be attained if we rejected the working agent from the cylinder at a temperature approaching that of the atmosphere, say some 70°, or some 530° absolute. As a fact, in the gas engine, the temperature of the exhaust is about 1,300° or 1,400° absolute. Now the lower we can reduce this 1,300° or 1,400° the more heat we shall utilise, and the greater power we shall obtain by a given consumption of gas in our engine. The efficiency of 22 per cent., of which I have told you, would be largely increased, and some of the 40 per cent. of this head of loss would be put upon the right side of our balance-sheet, and would be utilised.

Messrs. Crossley Brothers are making efforts in this direction, which is probably the most hopeful in which to look for improvement.

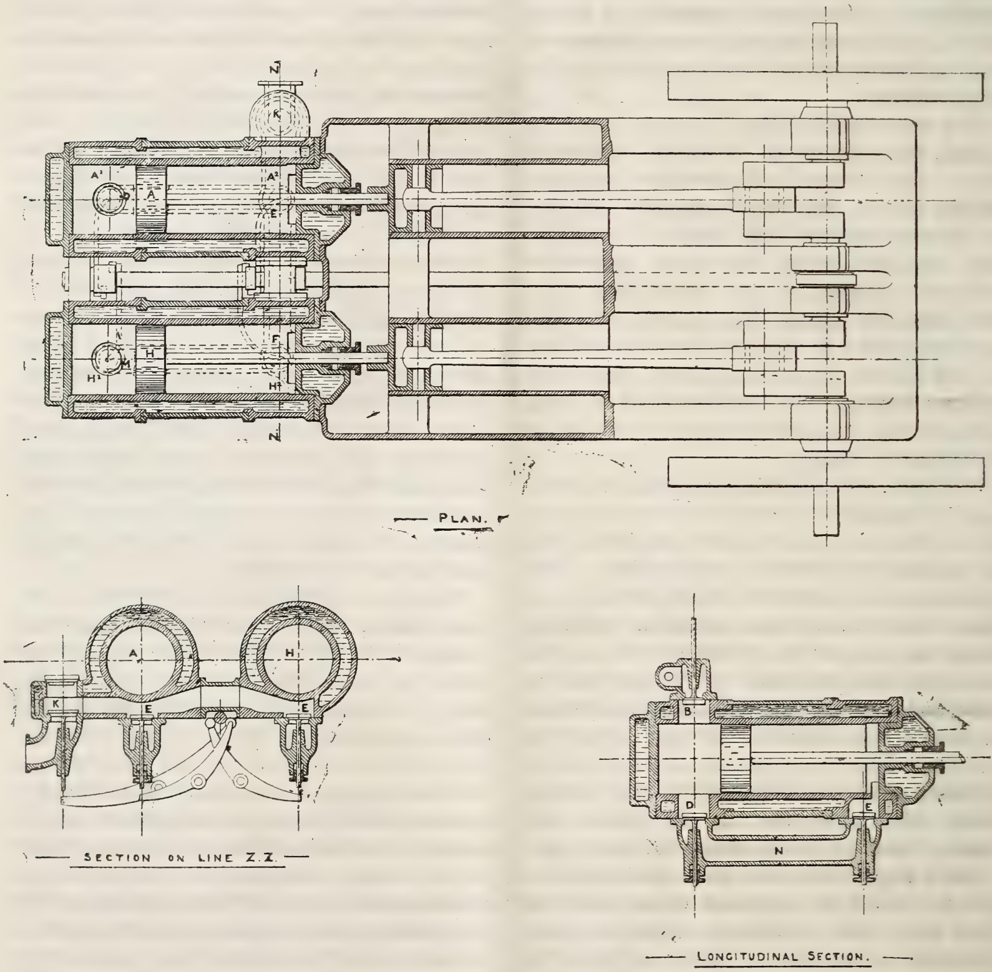
I will ask you to look at the three views shown on Fig. 31 (p. 756); these are from a tracing supplied to me by Messrs. Crossley. You will see that we here have two double-acting cylinders, each with its piston, piston-rod, and connecting-rod, these rods being attached to cranks on a crank shaft, the cranks being placed at the same angle, so that the pistons move in and out together.

Roughly described, the action of the engine is as follows. One of the cylinders draws in a charge of explosive mixture behind its piston as the pistons go out; the pistons return, the charge is compressed, then ignited, and the pistons go out again—being driven out by the force of the explosion behind this one of them—and then the gases, instead of being allowed to exhaust directly into the atmosphere, are, by means of the valves which are shown, allowed to pass to the other side—the forward side—of both pistons, and act there on both, to drive them back again, and to drive out the products of combustion from behind that piston of the cylinder in which combustion has taken place. Whilst this has been going on, the other cylinder has had its charge drawn in by the forward movement of its piston, has had it compressed by the return stroke and the charge is, at this moment, ready for ignition. When this ignition takes place, the two pistons are driven forward together, expelling into the atmosphere the expanded products of combustion from the front ends of both cylinders.

You will see the "cycle" in this engine is, therefore, that each cylinder has, in succession, a charge exploded behind its piston, driving both the pistons outwards; that then the expanded gases pass to the front side of both the pistons, which are, in succession, put into communication with the back parts of the two cylinders, and thus receive and further expand, the charges which have had a preliminary expansion during the forward movement of one piston in one cylinder, whilst the pistons were moving outwards.

It seems to me that some such form of compound engine as this is the one which will, in the near future, increase the efficiency of the present "simple gas engine," in a manner

FIG. 31.—CROSSLEY'S COMPOUND GAS ENGINE.



somewhat similar to that in which the efficiency of the "simple steam engine" was increased by development of the "compound steam engine."

You will realise that there is, incidentally, an advantage with such an engine as this, or in it the regularity of turning effort on the crank shaft approximates to that which we found to exist in the double cylinder steam engine.

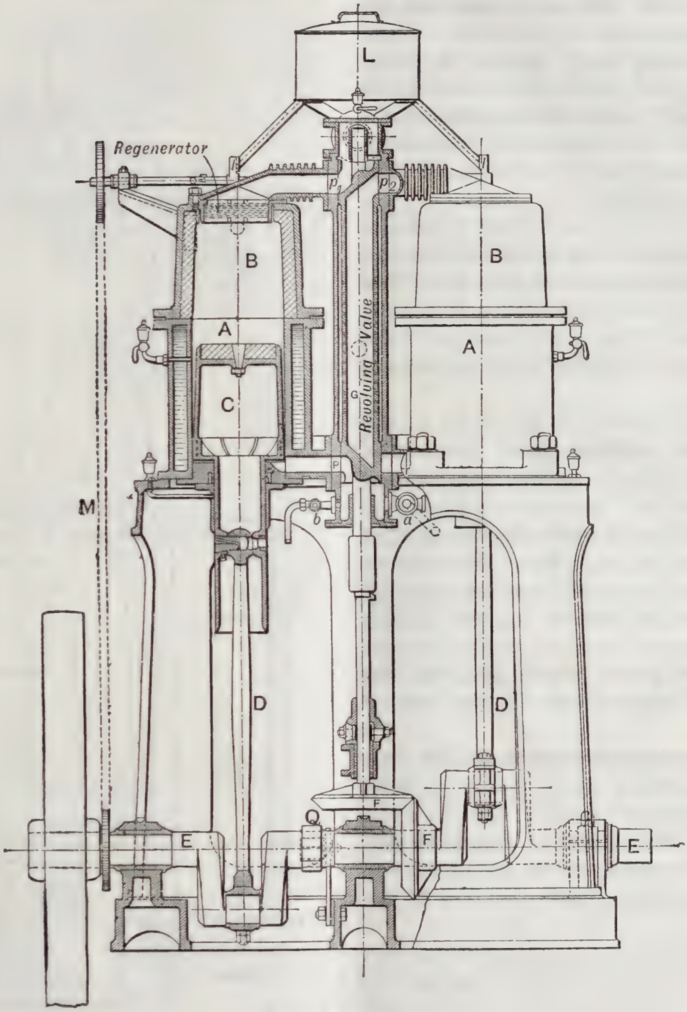
No record of the gas engine would be complete unless mention were made of the late Sir William Siemens. The patents taken out by him in connection with the gas engine—the "internally fired" engine, as I have called it—form of themselves a most complete and

compendious record or statement of the progress and development of the theory and practice of gas engine construction.

Most of you know it was due to his genius and perseverance that the regenerator suggested by Stirling has been developed, and has been utilised to such a great extent in the arts and manufactures. In fact, among engineers the name of Siemens is almost invariably associated with the thought of the "regenerator."

The application of this apparatus to the gas engine has been the subject of many patents, and has commanded the attention and thought of many minds, the idea being to allow the heat of the exhaust, as it leaves the engine,

FIG. 32.—SIEMENS'S REGENERATIVE GAS ENGINE.



Front Elevation.

to be absorbed, or "picked up," by the regenerator, this heat being once more given up to the fresh incoming gaseous charge, thus allowing some of the heat to again pass into the engine, and to some extent preventing the enormous loss due to the heat passing away in the exhaust.

I will only trouble you with diagrams illustrating one of Sir William Siemens's later ideas for the utilisation of this waste heat in gas engines by means of a regenerator. Diagrams Nos. 32 and 33 are taken from his patent drawing of 1881, No. 2504, which was for "Improvements in Gas Motors and Producers."

He states in this patent that the object of

his improvements was, "To simplify the construction and operation of the apparatus, and to utilise more fully the heat developed by the combustion of the fuel employed."

You will see, according to the two views, that this was a vertical engine, having two cylinders, A B, A B, the lower part of each cylinder being cooled by water circulating through the water jacket surrounding it, the upper part, in which combustion took place, being lined with some material refractory to heat, such as fire-clay. There are two cylinders, each having a piston and connecting-rod, these being attached to cranks at opposite angles on the crank shaft. Between the two cylinders there is a revolving cylindrical valve, driven from the crank shaft by means of bevel gear.

The valve as it revolves admits the explosive mixture, and allows of the exhaust of the products of combustion from both cylinders. You will see that the pistons are deep, and that the bearing portion of them is on the metal at the lower portions of the cylinders where they are water-jacketed.

The explosive mixture is drawn in at the bottom of the cylinders, and below the pistons, as they move upwards, and is compressed by them as they come downwards, being delivered into the vertical reservoir, R, at the back of the engine. From this reservoir the explosive mixture is allowed to pass by the revolving valve into the top end of each cylinder alternately, through the various thicknesses of wire gauze which form the regenerator, and which block the top ends of each cylinder.

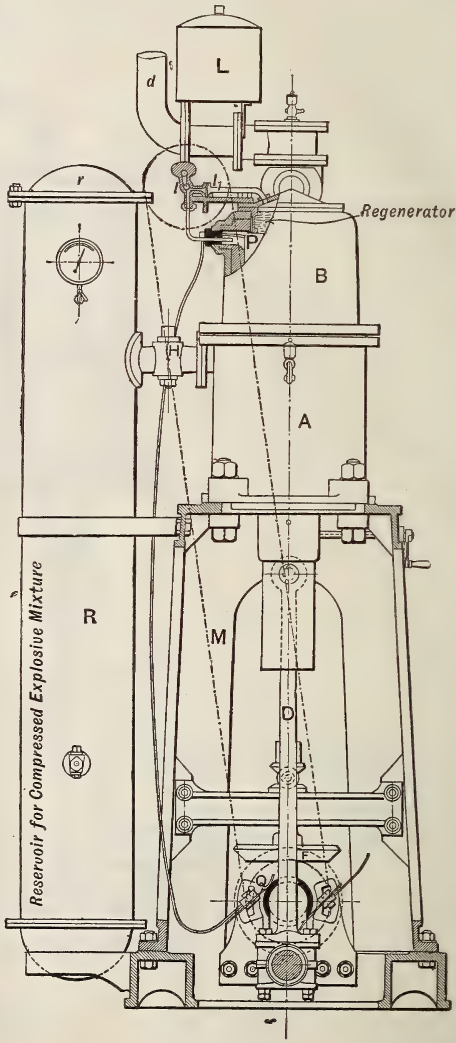
The mixture when admitted to the top ends of the cylinders, being already compressed, as it is, is fired, and the idea was that the flame of combustion would not be communicated through the wire gauze of the regenerator to the explosive mixture under pressure in the reservoir.

In this engine the non-absorbent refractory material lining the upper portions of the cylinders should not absorb the heat produced by the explosions, and, if combustion was not communicated through the wire gauze regenerator to the mixture under pressure in the reservoir, then a most satisfactory ignition should take place in the cylinder.

You will see that in this engine Sir William Siemens proposed to utilise the principle embodied in the "Davy" lamp, and thereby to be enabled to burn in the working cylinders an explosive mixture, without the explosion being communicated to the mixture which was under compression in the reservoir.

The ignition in this engine was performed by means of an electric spark from a dynamo, the armature of which was secured to the crank shaft of the engine itself. Whether an engine in exact accordance with the design in this patent was ever made, and whether, if it was made, it worked satisfactorily, or was capable of being made to work satisfactorily or not, I cannot say. It seems to me, however, it illustrates that which was in the mind of Sir William Siemens as

FIG. 33.—SIEMENS'S REGENERATIVE GAS-ENGINE.



Side Elevation.

late as the year 1881; after he had been designing, patenting, and experimenting with heat engines for many years, and when, therefore, remembering, as we must, his great and profound knowledge of the science of heat, and the vast experience which the large amount of practical work he had done must have given him, his mind must have been ripe and ready to produce an engine which should contain within it the germs of successful and of economical working.

Further, some of the improvements shadowed forth in this patent of Sir William Siemens are improvements which there is no doubt will, one day, be successfully utilised in practical work.

I have, invariably, in speaking of the efficiency of the gas engine as compared with that of the steam engine, used this same black cube to represent the fuel put into the boiler in the case of the steam engine, and also to represent the heat units supplied to the gas engine; and I have from this deduced the relative efficiencies of 11 per cent. of the steam engine, and of 22 per cent. of the gas engine, shown you by the red cubes.

I am now going to suggest that I have again treated the steam engine unfairly in making this comparison between the two forms of engine. I do not think that it is at all fair that the amount of heat put into the coal when it is in the gas retort, in order that the gas may be distilled from it, should be neglected.

The heat of this coke—the coke burnt under the gas retort—is really the latent heat of gasification of the solid coal, and is of as much effect in enabling us to obtain our gas engine efficiency as is the equivalent portion of the heat of the solid fuel put into the boiler furnace to vapourise the water. We should remember this when dealing with a gas from which we afterwards produce motive power in our gas engine cylinders.

I will not attempt to put this into figures, but will ask you to bear it in mind when you feel inclined to condemn that good old servant —the steam engine. But economy in the gas engine can be obtained by the use in that engine of some other form of gas than the ordinary lighting coal gas supplied by the gas companies. I do not mean economy in the sense of a lessening of the quantity consumed, but only economy in the cost of the working agent for each indicated horse-power.

"Dowson" gas is well known as a gas produced from anthracite coal or from coke, and produced at a cost, as compared with ordinary lighting gas, of from 1-10th to 1-7th; and although nearly four to five times the volume of Dowson gas is required to obtain the same horse-power in a gas engine as is obtained when lighting gas is used, yet the original cost of this gas is so much less than that of lighting gas, that the use of Dowson gas for power purposes is cheaper.

There has been great excitement in the newspapers of late about "water gas," as it is termed, and about the economical results which, it is said, will be obtained from its use.

Report says this gas has a very much higher calorific power than ordinary lighting gas, and costs slightly less than 4d. for each 1,000 cubic feet. If this is so, and if the supply of water gas for heating purposes ever becomes in any town a practical success, its use for gas engines in that town may probably enable an economy in the cost of power production by gas engines to be realised, largely in excess of any of which we are at present cognisant.

To sum up this portion of our subject. It does seem that with these "internally fired" gas engines, with the economical advantages arising from the mode in which the power developed by them is governed, the prophecy of our text will be shortly realised. Already such engines are, as I commenced by telling you, the successful rivals for small powers of the steam engine. Why the rivalry should be limited to small powers is difficult to understand. The only reason of importance with which I am acquainted is involved in the difficulty which is experienced in starting; but in these days, when for steam engines of any size a separate small engine, called a "barring" engine, is arranged so as to work upon the fly-wheel, and thus to get the main engine into slow revolution (the small engine being automatically thrown out of gear as the main engine increases its speed)—in these days, as I have said, when such small engines are common, there should be no difficulty—no prejudice even—against the adoption of similar small gas engines to start the larger gas engines into motion.

Remember, as the volume of the cylinder increases in the larger gas engine, the relative cooling surface due to its internal circumference decreases, and therefore some portion of the loss arising from the cooling effect of the jacket water will be eliminated, even if there should be no further economical improvement.

Miscellaneous.

THAMES POLLUTION.

The general report of the conservators of the River Thames, from the 1st of January, 1888, to the 31st of December, 1888 (ordered by the House of Commons to be printed 22nd of July, 1889), was issued on the 6th inst.

In an appendix (p. 189) to the report of the annual conference on water supply, held at the Society of Arts, 15th and 16th of May, 1879, there was given some history of the Conservancy Board from its establishment in 1857, with an outline of the previous work of the Lord Mayor and Corporation of the City of London as conservators of the river "from time immemorial." Abstracts from the first twenty reports, down to 1877, were also added.

The Act of 1857, which constituted the Board, and that of 1864, which did little more than raise the number of conservators from 12 to 18, gave no power to prevent the pollution of the river by sewage.* It was the third Act (1866), called the Thames Navigation Act, which by its 63rd section gave this power. The penalty for allowing any sewer or drain to open into the Thames was fixed at £100, with an additional "£50 for every day during which the offence is continued." The control of the conservators was then also extended from Staines, where it previously ended, up to Cricklade; and over this Staines to Cricklade portion it was that power was first given to stop sewage inflow. The power over the portion from Staines downwards was added in the following year.

Prior to this the chief duties of the conservators had been in reference to navigation, such as the care of locks, keeping channels open by dredging, and preventing obstructions, maintaining weirs, &c. These duties are still not only continued but augmented, though since 1866 the chief interest in the annual report has been in the sections that refer to sewage pollution, as so large a proportion of the whole of London draws its supplies of drinking-water from the Thames.

The 52nd section of the Act of 1866 made it the duty of the conservators to keep the surface of the river "effectually scavenged" by their own officers. Their power to prevent sewage pollution was by giving notice under their common seal to the person or body responsible for the inflow, requiring them to discontinue it within a specified time, not less than one or more than three years.

In the first year after this Act was passed, notices were served on over 30 authorities between Oxford and Sunbury to discontinue their sewage passing into the Thames, and 77 convictions were obtained against owners of gas, chemical works, &c.

The progress of the great work of purification which the Commissioners had to control can be traced down to ten years ago in the abstracts from the first 20 reports given as above mentioned, and in the return* to the House of Commons of the result down to 1876 of the notices served by the Conservancy Board. A review of the work done shows how much slower than was expected this progress was.

In 1877, ten years after action was first taken, the report gave hopes that "all the sewage above the intakes of the metropolitan water companies will soon be diverted from the river." But even in next year's report it was stated that Oxford and Windsor had not completed their sewage works.

The work of the Conservators had been increased by widening the area of their control over tributary streams since the 1866 Act. That and the Act of 1867 gave them power over three miles each side of the river, that of 1870 over five miles, and that of 1878 over ten miles; and the reports correspondingly show supervision over the mills, chemical works, &c., within the limits each side.

Among the reports since those given in abstract, that for 1881 contained the following passage:—"The river above the intakes of the water companies is now practically free from sewage contamination."

This last report just issued illustrates how needful is the constant supervision of the Board. In addition to the inspectors they already had, mention is made of another inspector appointed to the care of the river between Staines and Teddington, with the tributary streams, and the reorganisation of the staff that is in charge between Staines and Cricklade. The latter "now consists of a chief inspector and assistant inspector, and two river keepers, who are provided with a steam launch and other boats necessary for the performance of their duties." This, it is stated, has enabled the inspection of the tributaries to be more effectual.

The troubles with the Staines Local Board, and with the Chertsey rural sanitary authority, are spoken of as likely to be soon satisfactorily settled.

In the Staines cases, the Court of Crown cases decided "that there was a prescriptive right in certain individuals to send drainage from their houses" into a particular sewer, and the Board could not stop them by injunction or action, nor stop up the drain.

The amicable end of the case is that an assurance has been given "by all the individuals in question, except one who is abroad, that they will prevent the further pollution of the Thames from their premises."

The Chertsey case has reference to the question of dealing with the sewage at Weybridge. The conservators opposed the proposed scheme, fearing it would be a source of pollution in times of flood. The

* The £20 penalty (Act of 1857, § cii.) for allowing "offensive matter to flow" into the Thames was found practically useless.

* Accounts of Papers, 1876, vol. lxx, p. 641.

sanitary authority has given assurances it is taking all steps in their power to prevent pollution.

In reference to various sewage works that have been erected at various places on the river, the report states:—"The sewage works established at various towns on the river and its tributaries are very closely watched, and additional precautions are taken to prevent the possibility of any pollution escaping from those works into the river."

Compared with the vast bulk of sewage that flowed into the Thames above the intakes of the water companies at the time the 1886 Act was passed, the statement of the 1881 report, that the river "is now *practically* free from sewage contamination," seems borne out by all subsequent reports, including this last.

The conservators' officers even have "strict orders to watch house-boats and steam launches, with a view to the detection of any pollution from those vessels."

The report contains, as usual, its balance-sheet (this year over £85,000 for "lower," and over £23,000 for "upper navigation"), and an account of its work generally. Reference is made to improvements in "the craft and appliances for raising sunken vessels. Among the thirty-seven sunken vessels raised during the year were "seven steam vessels measuring 6,872 tons."

Although probably most people regard prevention of pollution as important mainly in connection with drinking supplies, yet the condition of the river itself, within the metropolis, threatened to be a danger as well as a nuisance, and thirty years ago excited considerable alarm. This, however, was largely due to the sewage of the metropolis itself. (See *Journal* No. 1,642, May 9, 1884, p. 636, col. 1.)

As some clue to the gradual development and the work of the Board in regard to pollution, the following has been compiled;—

The Lord Mayor and Corporation had been Conservators of the Thames between the city stone at Yantlet (or Yenleet) Creek, Kent, up to the city stone at Staines, Middlesex, from time immemorial.

1795.—The maintenance and improvement of the navigation of the Thames from Staines, Middlesex, to Cricklade, Wilts, was placed under the control of the "Upper Navigation Commissioners" by the Upper Navigation Act of 1795.

1855.—The Act creating the Metropolitan Board of Works (1855) caused the introduction of a new boundary line that had to be subsequently recognised by the Conservators—viz., "the western boundary of the district under the authority of the Metropolitan Board of Works," sometimes defined as "the western boundary of the metropolis."

1856.—All the metropolitan water companies drawing their supplies from the Thames were compelled by the Metropolis Water Act of 1852 to have their works for intake removed to above Teddington Weir by the year 1856. The Chelsea Company was allowed one year longer.

1857.—Establishment of the Thames Conservancy Board, with jurisdiction similar in area and in kind to that of the old Conservators (the Lord Mayor and Corporation) by the Act of 1857.

1866.—Control of Thames from Staines to Cricklade transferred from the "Upper Navigation Commissioners" to the Conservancy Board, and power given to exclude sewage from flowing into that part of the river, or into any stream or watercourse three miles each side of it, by the Act of 1866.

1867.—Power given to exclude sewage from flowing into the river between Staines and the western boundary, or into any stream or watercourse for three miles each side of it, by the Act of 1867.

1870.—The "three miles" of the two previous Acts extended to "five miles" by the Act of 1870.

1876.—Return to the House of Commons, showing the extent to which the notices served by the Board on public bodies to discontinue sending sewage into the Thames had been complied with. Only four large towns with works still incomplete.

1877.—Works at Abingdon, Reading, and Windsor finished.

1878.—Control of conservancy still further extended from "five miles" to "ten miles" on each side by Act of 1878.

[The companies supplying the metropolis with water from the Thames were compelled to construct filter-beds by the Act of 1852. This is quite independent of the Conservancy.]

THE UNITED STATES LUMBER TRADE.

The chief of the Forestry Division of the United States Department of Agriculture says that England heads the list of the countries to which are shipped the largest quantities of lumber. This country is closely followed by the West Indies, the Argentine Republic comes next, and then Austria, Germany, and Canada, with almost equal participation in the export trade. In wood manufactures, which form less than one quarter of the exports of forest products, agricultural implements and household furniture alone are of importance, each with about £450,000 worth. England, France, the Argentine Republic, Austria, and Germany, together take over two-thirds of the United States' wood manfactures. France and the Argentine Republic are the best markets for agricultural implements. The cooperage industry finds its best customers in the West Indies, with £200,000 worth. Spain and Portugal come next with, together, £150,000, and England next somewhat less than £100,000. It is stated, as a curious fact, that the United States furnishes to France, which imports annually from 35,000,000 to 40,000,000 staves, less than £20,000 worth of American cooperage wares. The returns of imports into the United States from various countries show

that British North America is the only country which comes into competition to any extent with the United States native forest products in raw shapes, while Germany, Austria, France, and England send a little over £200,000 worth of wood manufactures. Nearly two-thirds of the imports into the United States of forest products are like indiarubber, gums, cork, dye woods, and cabinet woods, not produced in that country. The exports during the year 1888 have increased by over £700,000, or 12½ per cent. The increase is largely represented by raw material, logs and hewn timber, and boards, deals, &c., while manufactured articles contribute only £160,000 to the increase. The largest exports of raw materials are in manufactured lumber and in naval stores, the next largest are cooperage timber and logs.

ELEMENTARY EDUCATION IN FRANCE.

The French *Journal Officiel* quotes the following figures relating to the statistics of education in France, which have been taken from a recent official report. In 1882, there were in France (excluding Algeria) 75,635 schools, while the number had risen in 1887 to 80,209, an increase of 3,711 public, and 863 private schools. The number of public primary denominational schools fell from 11,265 to 9,097, while the number of public primary secular schools increased from 51,732 to 57,611. On the other hand, the number of private denominational schools in 1882 was 8,160—in 1887 it had increased to 9,565. In this number girls' schools figured for nearly seven-tenths. In the same period the number of secular private schools fell from 4,478 to 3,936. The total number of masters or mistresses in the public or private schools, including dames' schools, in 1882 was 138,536, and in 1887, 145,668, of whom 103,008 were engaged in public, and 42,660 in private instruction. The number of lay male teachers has increased by 5,372, and of lay female teachers by 8,544. The total denominational staff—which in 1882 comprised 52,450 masters and mistresses, both in public schools and private elementary schools, including dames' schools—has not varied to any great extent. At the present time it numbers 51,666, of whom 18,056 are engaged in public, and 33,610 in private instruction. The pupils on the register in 1882 numbered 5,341,211, not including those in dames' schools. In 1887, they were to the number of 5,526,365, that is an increase of 185,154, or 3 per cent. for the quinquennial period. The secular public schools gained 294,786 on the register, while the public denominational schools lost 209,474. During the same period, however, the lay private schools had 43,537 fewer pupils, and the denominational schools 143,379 more pupils.

Obituary.

Sir James Marshall, K.C.M.G.—Sir James Marshall died of pneumonia at Margate on the 9th inst., after a few days illness. He was born in 1829, educated at Exeter College, Oxford, where he graduated in 1854, and called to the Bar at Lincoln's Inn in 1868. For some time he was classical master in the Birmingham Oratory School, and then went the Northern Circuit. He was appointed chief magistrate and judicial assessor to the native chiefs of the Gold Coast in 1873. In the Ashantee war of 1873 he led the Cape Coast chiefs and levies, and received a medal for his services. He was Senior Puisne Judge of the Supreme Court in the Gold Coast colony 1876-9; Chief Justice, 1879-82. He was appointed Chief Justice of the territories of the Royal Niger Company, in Africa, 1887. Sir James Marshall was created a Knight Bachelor in 1882, a Companion of the Order of St. Michael and St. George, in 1886, and a Knight Commander of the Order in 1889. He was a member of the Society of Arts, and was Executive Commissioner for the West African Colonies at the Colonial and Indian Exhibition of 1886.

General Notes.

Traffic of the Suez Canal, 1888.—According to the last report of M. Ferdinand de Lesseps to the shareholders of the Suez Canal Company, 3,440 ships passed through the canal in 1888. From these, receipts to the amount of 63,037,618 francs were realised, while receipts from passengers amounted to 1,838,957 francs, and from the transit service to 366,045 francs. The total traffic receipts amounted therefore to 65,242,620 francs, an increase of 7,117,245 francs over the previous year, or 12·24 per cent. Vessels to the number of 192, or an increase of 20·75 per cent. on 1887, passed through the canal for the first time last year. The number of ships drawing more than 7 metres of water was 971, or a proportion of 28·23 of the total; 105 had a draught of 7·49 metres, and 2 of 7·50 metres. Night traffic in the canal continues to increase. In 1888, 1,608 ships—that is to say, 46·74 per cent. of the total traffic—have passed through with the aid of the electric light. The average of the whole journey per ship in 1887 was 34 hours 3 minutes, a diminution of 2 hours 8 minutes on the preceding year. In 1888 the further diminution was 3 hours 18 minutes, or an average total journey of 30 hours 45 minutes only.

Journal of the Society of Arts.

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FRIDAY, AUGUST 23, 1889.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

EXAMINATIONS, 1890.

The subjects of examination are—1. Arithmetic; 2. English (including composition and correspondence, and précis writing); 3. Book-keeping; 4. Commercial Geography; 5. Shorthand; 6. French; 7. German; 8. Italian; 9. Spanish; 10. Portuguese; 11. Russian; 12. Danish; 13. Chinese; 14. Japanese; 15. Political Economy; 16. Domestic Economy; 17. Theory of Music; 18. Practice of Music; 19. Practical Commercial Knowledge.

These examinations will be held on April 14, 15, 16, and 17, with the exception of that in the Practice of Music, which will be held during the week commencing on the 2nd of June.

The Programme is now ready, and copies can be obtained gratis on application to the Secretary.

Proceedings of the Society.

CANTOR LECTURES.

HEAT ENGINES OTHER THAN STEAM.

By H. Graham Harris, M.Inst.C.E.

Lecture IV.—Delivered May 27th, 1889.

Syllabus.

Petroleum Engines—Brayton and others—Other Forms of Heat Engine—Gunpowder Pile Driver—Gun-cotton Engine—Honigman's Caustic Soda Engine—Mixed Air and Steam Engine—Ether and Steam—Du Trembley—Recent American Experiments—Yarrow—"Arktos"—Electrical Heat Engines—Thermo-pile—Edison—General Conclusions.

We spent our time last Monday in considering the gas engine, with its mechanical difficulties and its possibilities.

Although there is very much more to be said about the gas engine, I think it will be better for us to devote the time at our disposal to-night to dealing with some other forms of heat engine from which motive power is obtained, and also with some other forms of heat engine in which the heat does useful work although it does not produce motive power. These latter heat engines are in themselves interesting, and we shall find they illustrate in a marked manner the advantages and disadvantages to be derived from the use of some of the other bodies or materials, which our previous lectures may have led us to think might well be utilised for motive power production, in addition to those already employed.

We will first deal with petroleum engines, these being nearest in succession to the gas engine. There are some few of these in actual practical work for small powers. The interest in them and in their working is great, and their use will without doubt be at once largely developed. Their mode of working, and the manner in which the power developed by them is regulated to suit the necessities of the work they are doing, is similar to that of the gas engine, and the "cycle" of their working is identical therewith; but their efficiency is practically, at present, not quite so high as that of the gas engine. In petroleum engines, however, as the fuel is liquid, there is a certain amount of theoretical loss due to the latent heat of vaporisation of the liquid, although in those in which the oil used is very volatile, this loss is but small. In one of these engines, as we shall find, the heat of the exhaust, which would otherwise be wasted, is utilised for this vaporisation. In the gas engine itself a similar loss does not occur, for the heat which is rendered latent is, as I told you last week, that of the coke used under the gas retort to gasify the solid coal.

With petroleum engines means have to be provided for delivering the liquid fuel automatically and at regular intervals into the working cylinders, in such a manner and in such a state as will render it capable of easy vaporisation. This is usually attained by pumping

the petroleum into the cylinder, delivering it there as a "spray," a regular quantity being supplied for each explosive or working stroke of the engine.

One of the greatest practical difficulties which has been experienced with the petroleum engine is that of keeping the oil inlets for the spray and other internal portions of the engine clean, and preventing them from being clogged by the products of imperfect combustion of the oil. This is a difficulty which was, to some extent, experienced with the slide valves of gas engines during one period of their development, but which has now almost entirely disappeared, even in those engines where such valves are still used.

An engine in which liquid petroleum was to be employed was suggested by the late Sir William Siemens, as early as 1860. In 1873, Brayton patented a petroleum engine which, with very slight modifications, could be used either with petroleum or with gas; many of these were constructed and put to work, more especially in America.

The more recent forms of petroleum engine are those known as the "Spiel" engine, the "Priestman" engine, the "Eteve" engine, and the "Shipman" engine. The oil used with the Spiel engine is of a quality having a much lower flashing point than that which is used in the Priestman engine, and it is, therefore, to that extent, more liable to accident.

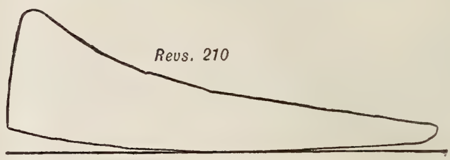
A trial of a Priestman engine was made at the meeting of the Royal Agricultural Society, last year, by the Society's consulting engineer, Mr. Anderson, and a record of this trial, with a description of the engine, is to be found in the recently published volume of the Society's proceedings.

From this it appears that the oil consumption of this engine, per brake horse-power per hour, was equal to 1·73 pounds, and the petroleum costing, as it does, about 6½d. per gallon, the cost of working was about 1½d. per brake horse-power per hour. This is of course much in excess of the cost of working a gas engine, even where gas is as high in price as 3s. 6d. per thousand cubic feet.

It is in the Priestman engine that the heat of the exhaust is utilised to raise the temperature of the mingled air and oil before it passes into the cylinder, and this mingled air and oil is compressed before the charge is fired, the firing being done electrically. The engine is governed by regulating the quantity of oil let into the cylinder, and the amount of air which is mixed with it. In this engine, therefore, as in the gas engine, the governor approximately regulates the amount of fuel consumed.

You have shown by Fig. 34 an indicator diagram, taken from a Spiel petroleum engine, and you will see that it is similar to the indicator diagrams which I have shown you are obtained from the ordinary commercial gas engine—such as that of Messrs. Crossley, or the Atkinson, or the Griffin—and you will realise that, judging from the curves of expansion and compression in this diagram, the engine should be (as it is) a reasonably economical one.

Fig. 34.—Indicator Diagram from a Two Horse-power Petroleum Engine.



The efficiency of the petroleum engine, however, and its cost of working do not, as yet, equal that of the gas engine, but the petroleum industry is one which is day by day increasing. There are no theoretical reasons, of which I am aware (except the need for vaporising the oil, of which I have already spoken), why the petroleum engine should not be at least as handy, as efficient, and as simple as the gas engine; and, in my judgment, it is not at all improbable—nay, it is almost certain—that engines of this type will, before long, join successfully in the rivalry between the steam engine and the gas engine. The amount of heat lost in the vaporisation of the petroleum is very slight, and, in any case, this would be a small head of loss as compared with others existing in these engines, and also in the gas engine.

The petroleum engine—like the hot-air engine—has an advantage over the gas engine from the fact that there is no need to turn its fuel into gas before it is employed in the engine, thus saving the costly apparatus necessary for the gas engine where its fuel cannot be obtained direct from the gas company's mains.

Further than that, Priestman's engine, as we have seen, utilises some portion of the heat which would otherwise pass away in the exhaust, to heat up the fresh charge of mingled air and oil before it is allowed to pass into the working cylinder, thus to some

extent eliminating the loss due to the "latent heat of vaporisation."*

The similarity between petroleum engines and gas engines is such that it seemed to me I might well describe them in the general terms I have used, and that, as our time is limited, I need not go into any great detail, as, for our purpose, the generalities are sufficient after the full description given of the gas engine.

But the theory of our first lecture told us that the working agent we required to use in our heat engine for power purposes should (in order to give us the greatest useful effect for the least possible consumption of fuel) be one which would not dissipate in any way—either for vaporisation or in order to raise its temperature through any given range—a large quantity of the heat put into it; that is to say, other things being equal, some body whose latent heat and specific heat is low.

While bearing this in mind, let us consider for a while some of the various suggestions which have been made. Although in many cases the engines based on these have failed in practice, yet each suggestion will serve to illustrate some portion of our subject, and will, I hope, teach us what are some of the difficulties which have to be encountered; and will enable us more fully to realise what a thoroughly satisfactory working agent should be.

Proposals have been made to utilise, for power purposes, some of the various bodies wherein a large volume of hot gas is developed on rapid combustion or explosion—that is to say, bodies such as gun-cotton, gunpowder, &c. A gun-cotton engine for driving tricycles has been suggested. I am told one was made, but whether it was ever tried or used I cannot learn. In this a series of small gun-cotton cartridges or "pellets" were to be exploded in rapid succession, and it was proposed to use the force of these successive explosions to drive the tricycle. There is no doubt the idea of the inventor was that, as the gun-cotton has little weight, and as the force produced by its explosion is great, therefore it would be possible to carry on the tricycle a sufficient store of "power" for a long journey. You will of course see that this idea is a fallacious one, and that the engine would probably be impracticable because of the difficulty of satisfactorily controlling the force of the explosions in so light a machine as a tricycle must of necessity be.

Further, I can quite imagine that some little trouble and difficulty would arise (and probably the rider himself would "arise") if the whole string of cartridges or pellets went off together, an accident, I should think, not at all unlikely to happen. But the explosive effect of gun-cotton or gunpowder has been applied in a most admirable manner, and in a way which theory tells us is approximately perfect, for the purposes of pile driving.

I want to describe this pile-driving engine to you, not only because I think it is a most admirable adaptation of the "disadvantages" of gunpowder for a working agent—an adaptation which turns these disadvantages into practical advantages—but I also want to use it because it emphasizes a portion of the theory of our first lecture which has cropped up two or three times since. I hope the description of this pile-driving engine will thus help to weld together all that I have told you in respect to this point.

Let us look at the diagram Fig. 35 (p. 766). Here you have the ordinary pile-driver engine frame, consisting of the two front vertical runners, or guides, with the back angular stays or struts, these being braced together in the ordinary way; and you also have, running up and downin the front "runners," a heavy weight, or "monkey," as it is technically called. Fixed to the top of the runners you have a cylinder, E, with a closed upper end, but open at the bottom, and secured to the top of the pile there is another cylinder, C, closed at the bottom and open at the top.

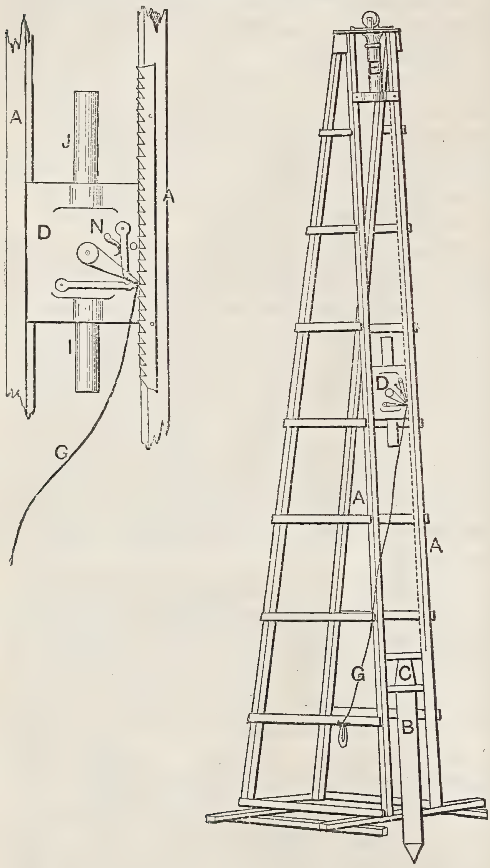
On the upper and on the lower side of the weight, or "monkey," there is a piston or ram, the upper ram passing into the top cylinder when the "monkey" is right up, and the lower one passing into the bottom cylinder when the monkey is down.

There is a rack on one of the runners going from top to bottom, and there is a pawl on the monkey, which can be kept in contact with the teeth of this rack by means of a small lever controlled by a spring, the pawl being taken out of gear with the rack, when desired,

* Since the above statement as to petroleum engines was made at the lecture of the 27th of May, the Windsor Show of the Royal Agricultural Society of England has been held. There, many forms of petroleum engines were exhibited, in addition to those enumerated above. All of the engines were, however, for small powers. Two or three makers showed portable engines of this character, the engine, with its tank of oil, being carried upon wheels, so that it might easily be moved about from place to place. This portability is of great advantage for agricultural purposes, and is another invasion of the domain of the steam engine by other forms of heat engine for power purposes. There is no doubt that the development of these engines since the show of the Society of last year is very marked, and this development forcibly illustrates the prophecy of our text.

by means of a cord, having one end carried to the ground, and worked there by the man in charge of the pile-driver. If you will look at the enlarged detail of the monkey to the left of Fig. 35, you will see the monkey, lettered D, the rack on the right-hand runner, A, the pawl and levers, N, and the cord, G, with the ram, J, at the top of the monkey, and the ram, I, at the bottom.

FIG. 35.—GUNPOWDER PILE-DRIVER.



By this pawl and rack the monkey can be held suspended in any desired position, and can be released and allowed to fall at will.

This pile-driving engine works in the following way:—A series of cartridges or pellets of gunpowder, or some explosive, are provided, and one of these is automatically dropped for each stroke of the monkey, into the cylinder on top of the pile-head. The monkey comes down; the piston, or ram, on its lower side enters the cylinder on the pile-head, compresses the air within it, for which there is no means of escape, and compresses it to such an extent that the heat which it generates fires the explosive, which not only acts to drive down the pile, but also acts to drive up the monkey for the next stroke. In some respects the monkey resembles a shot projected from a gun, the pile being driven down (as the gun is driven backwards) by the recoil.

If the monkey goes up so far that the piston on its upper side enters the cylinder at the top of the engine frame, then the air within that cylinder, being compressed, helps to put the monkey again into more rapid motion downwards.

You will see that the action of driving-in the pile is due not only to the force of explosion of the cartridge or pellet, but also to the compression of the air in the cylinder on the pile-head, and that, most probably in all cases, the pile would have commenced its motion downwards, due to this compression at the time of explosion.

You will also see that this apparatus is practically similar in the theory of its working to the big gun which we used for illustration of the theory of our subject; but it is a big gun whose operations are continuous, so long as the cartridges are supplied to it.

One of its peculiar uses for our purpose is that it shows the practical advantage which has been taken of the heat generated by compression of a gas—the air—for it is this heat which fires the cartridge.

You will remember how I showed you that the heat generated by compression of the gaseous mixture in the gas engine, or at least some of it, was abstracted by, and passed away with, the jacket cooling water and was therefore wasted. But in the gunpowder pile-driver the proposition is to utilise the heat developed by compression of the air to fire the cartridge, the heat developed by combustion doing the work of lifting the weight of the monkey, as well as driving down the pile.

You will have realised, from many things I have said, that steam, in spite of its wastefulness, has numerous practical advantages when the question to be solved is the production of motive power from heat in a motive-power engine. It is practically its own lubricant, and it is only when we consider its disadvantages that we are at all led to the conclusion that there may be some other body (in which these disadvantages, or some of them, do not exist) which could be used as a working agent, and from which motive power might possibly be more economically obtained.

Many suggestions have been made with the

object of coupling with the water, or with the steam from it, some other working agent possessing advantages not possessed by the steam alone, thus obtaining a compound working agent having the advantages of the steam and of the other fluid or gas which may be mixed with it. Air has been suggested, and has been used with fair success for this purpose.

Suggestions have also been made for utilising the heat of the exhaust steam (the steam having first done its work in an ordinary steam engine) to vaporise and to generate pressure in the vapour of some other body which shall be used as a working agent; or, in other words, the suggestions have followed the line of reducing the outgoing temperature of the exhaust steam by causing it to give up its heat to some other body which vaporises at a low temperature, and which itself shall be used as a working agent in a separate cylinder; thus increasing the range of temperature through which the working agent passes, not by adding to the initial temperature, but by reducing the final temperature.

I think it would be well for us to consider two or three of the many suggestions, which are typical, and serve to illustrate the direction in which improvement has been, and should be, sought.

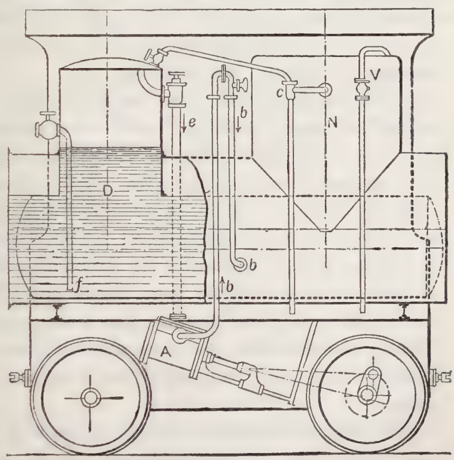
It has been said, and wisely said, that more is to be learnt from the consideration of engineering failures than from engineering successes. Our object is to learn, and I want you quite to understand that, although most of these suggestions of which I shall speak have not, from one cause or another, succeeded in practice, they each appeared to contain elements of practical advantage, and they will each serve to illustrate the points at present under consideration.

One of the most promising suggestions which have been made was that of M. Honigman, who proposed to absorb the exhaust steam from an ordinary steam engine by a concentrated solution of caustic soda, with the result that a large portion of the heat latent in the steam would be rendered sensible, and the solution of caustic soda, formed by the admixture of the steam with the soda, would have a resultant sensible temperature very much in excess of the sensible temperature of the steam put into it; that is to say, steam at 212° (or at boiling point), injected into a solution of caustic soda, having a specific gravity of 1·7, will cause the temperature of that solution to rise to a temperature of 374°, which is practically the temperature of steam at a pressure per square inch of 165 lbs. above the atmosphere.

Now if a boiler containing water or steam of, say, the temperature due to an ordinary working pressure of some 60 lbs. to 80 lbs. on the square inch, were placed in such a solution, the solution would impart some of its heat to the water or steam in the boiler, and this would be raised in temperature, and therefore in pressure. You will see the suggestion was that the heat of the exhaust steam should be utilised to increase the initial pressure and temperature of the steam passing into the engine to do work there. Of course, this was not a case of perpetual motion, or of getting "something for nothing," because the solution of caustic soda gradually became weaker and weaker as more of the exhaust steam was passed into it, and condensed into water there, so that the solution either required, after a certain time, re-concentration (that is to say, required that heat should be applied to it in order that the excess of water should be driven off from it), or a fresh concentrated solution, having a high specific gravity, was required.

Honigman applied the principle involved in his invention to the working of a tramway engine, and also to the working of a locomotive. You have a diagram of such an engine in Fig. 36.

FIG. 36.—HONIGMAN'S CAUSTIC SODA CONDENSER ENGINE, FITTED TO TRAMWAY ENGINE.



One of the earliest suggestions for the utilisation of the heat of the exhaust was that made by M. du Trembley about the year 1850.

Engines of large power upon this principle were fitted to several steamships which ran a

mail service for many years from Marseilles. The engine was known as Du Trembley's combined vapour engine, and the advantages which it was sought to obtain were those arising from the fact of the difference of the boiling point of different liquids—that is to say, the vapour (steam) of water, which boils at the temperature of 212°, was used to boil ether, the boiling point of which is, at atmospheric pressure, about 100° Fahr.

The engine consisted of an ordinary steam engine, supplied by steam in the ordinary manner from a steam boiler. The exhaust from this engine was allowed to pass into a vessel or box containing numerous small tubes, the ether being on one side of these tubes and the exhaust steam on the other. The exhaust steam gave up to the ether its heat, ether vapour under pressure was generated, and this vapour under pressure was used to obtain power in a separate engine. You will see that the vessel in which the ether was vaporised really became the surface condenser of the steam engine, the only difference being that the tubes in which the exhaust steam was contained were surrounded and cooled by ether instead of by water.

The ether vapour having done its work in its own engine, passed into a vessel like an ordinary surface condenser, where it was condensed by sea water in the same way as the exhaust steam is ordinarily condensed. From this vessel it was again passed to the vaporiser, where it condensed more of the exhaust steam, and in doing so was itself vaporised, and was then again used to drive the ether portion of the engine.

A full account of this engine, and of its performance, will be found in the proceedings of the Institution of Civil Engineers, in a paper read on the 8th of February, 1859, by Mr. J. W. Jameson. I gather from this paper that the coal consumption, when the ether vapour was used in conjunction with the steam, was only some 2 lbs. per indicated horse-power per hour, while with the steam alone the consumption was as much as 7 lbs. per indicated horse-power per hour.

Very careful records of working were kept, most elaborate experiments were made, and reports were published giving the results of these experiments; and theoretically—and, as a fact, in practice—there is no doubt that engines such as this were economical in coal consumption. But ether—in common with some other bodies having a low boiling point—is extremely difficult to confine, that is to say, the workmanship necessary to be used in all the various portions of the apparatus in which the ether has to be maintained under pressure must be very superior.

Further than this, ether is like air or gas, and unlike steam, in that you cannot readily detect a leak, and a mixture of ten of atmospheric air to one of ether vapour is explosive, as is a similar mixture of gas and air; ether vapour is also heavier than atmospheric air.

The practical difficulties arising from these differences between ether vapour and steam turned out to be very great. The ether vapour leaked from the joints; being heavier than the air, it fell into the bilge at the ship's bottom; in falling, it became mixed with a proportion of atmospheric air, thus forming an explosive mixture. As a fact, many accidents happened with these vessels, and after some years of working the system was abandoned; in spite of the economy before referred to, the engines were taken out of the vessels, and steam engines of the ordinary construction were substituted.

The suggestion embodied in this use of the vapour of ether (the vapour being generated by the heat of the exhaust steam from an ordinary steam engine, which heat is generally wasted) is one which, theoretically, should increase the effect to be obtained by a given amount of fuel, by that proportion of heat abstracted from the exhaust steam. It is one, therefore, which should increase the efficiency of any given steam-worked motive power producing apparatus. You will realise that what was really done was that a little more was added to the tail end of the indicator diagram.

These engines of M. Honigman and M. du Trembley are typical examples of the efforts which have from time to time been made to utilise some of that portion of the heat which is now wasted in the exhaust of the steam engine. You will remember that Messrs. Crossley are endeavouring to increase the efficiency of the simple gas engine by "compounding" it, and thus utilising some of the heat at present passing away in the exhaust. In all these engines economical improvement was sought, by endeavouring to reduce the temperature of the working agent as it leaves the engine, and, as I have said, to thereby add a "little more to the tail-end of the indicator diagram."

Let us now consider other modes which have been suggested for utilising a greater portion

of the heat in any given quantity of fuel, by the use of other working agents than steam, or than any of those to which I have already referred.

As I have told you, these other working agents do not theoretically possess some of the disadvantages which hamper us in the case of steam; although we shall probably find that in some of them, in practice, other disadvantages arise which render them useless for the purpose, or—perhaps I had better say —less useful than steam.

There has been published in the "Transactions of the American Society of Civil Engineers," for October, 1888, a paper by Mr. Magovern, on "Aqua-ammonia Engines," in which the question of obtaining a greater effect in a motive-power engine, by the use of some working agent other than steam, has been considered. One suggestion upon which he comments is that some liquid shall be employed having a lower latent heat of vaporisation than water, that is to say, some liquid which vaporises at a much lower temperature.

Mr. Magovern points out that most of the liquids possessing this lower latent heat of vaporisation are inflammable; that most of them require very accurate and satisfactory workmanship in the apparatus in which they are employed, in order to confine them; that in some cases the vapours produced from them are light, and that with these consequently a larger volume is necessary to carry the same available heat than is necessary in the case of steam, and that thus larger cylinders and more bulky apparatus generally would be required, in order to obtain an equal amount of work; and, after considering the whole matter, Mr. Magovern states that in his judgment the fluid which has more to recommend it than any other is *aqua ammonia*, which consists of ammonia in the gaseous state, more or less loosely held in solution with water. This may not be a chemically exact method of describing the combination, but it is near enough for our purpose.

It is, as we shall see directly, this fluid which is used by Mr. Perkins to produce intense cold in his "Arktos" apparatus. In the experiments by Mr. Magovern, the records of which I am about to give you, the use of this same liquid in lieu of water seemed to considerably increase the efficiency obtained from a steam engine. The fluid, as I have said, consists of ammonia in the gaseous state and water, the ammonia gas being absorbed, as it were, by the water, and held in solution, much in the same way as the gas in soda water is held in solution. In the case of soda water, a relief of the pressure allows of the discharge of the gas, while in the case of aqua-ammonia, the application of a small amount of heat will liberate the ammonia gas.

The amount of heat required to drive off the gas from the aqua-ammonia depends, of course, on the specific gravity of the solution. The principal difficulty which has been experienced with all apparatus designed to use this liquid for power purposes has been to condense the gaseous ammonia after it has performed its work in the engine. This has usually been done by bringing the gas into contact with water, and thus re-absorbing it and reproducing aqua-ammonia. The boiling point of liquid ammonia at atmospheric pressure is about $-32°$ Fahr. (equal to $64°$ of frost); and at a pressure of 105 lbs. on the square inch its temperature would be about $60°$ Fahr. The latent heat of vaporisation of liquid ammonia is 895 as compared with that of water, which is 966. The density of ammonia gas and of steam (the gas of water) are practically equal for equal pressures, and their specific heats are approximately the same; therefore, at the same temperature these gases each contain practically the same amount of heat. Further than this, the anhydrous ammonia in the form of gas, although it is poisonous, yet is not explosive when mixed with air, neither is it so very difficult of confinement. Many experiments have been tried to utilise this vapour for the production of motive power.

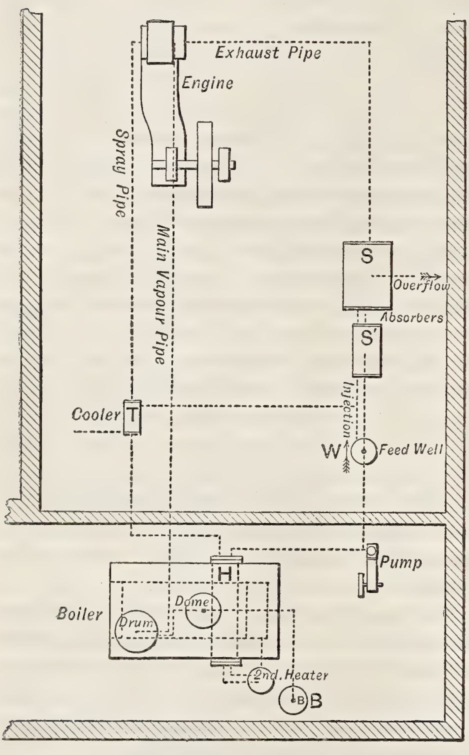
The apparatus with which the comparative experiments were made that Mr. Magovern records was that known as the Campbell apparatus, and you have in Fig. 37 (p. 770) one showing a plan of the general features of the plant used in the experiments.

You will see that in the outbuilding at the bottom of the diagram there is a boiler, in which the heat was imparted to the aqua-ammonia when this was used in the engine, or to the water when steam alone was used. In these experiments the engine was so arranged that it could, with very slight modification, be worked by steam in the ordinary way, or by aqua-ammonia vapour.

The engine was an ordinary Porter-Allen horizontal steam engine, of a type most common in America. Means were provided for condensing the steam, and returning the condensed steam to feed the boiler, when the engine was driven by steam alone, the same

thing being done when the aqua-ammonia was used, and it is upon the efficiency of this portion of the apparatus that its success depends. Precautions were taken (as they should be in such trials as these) to repeat and verify all the records obtained; and without to-night fully detailing the experiments which were made, it appears from the records of the tests that the coal consumed per indicated horse-power per hour, when aqua-ammonia was used,

Fig. 37.—Ground-plan showing General Features of Plant of Aqua-ammonia Engine.*

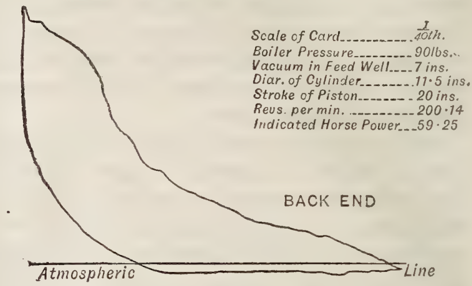


was, on an average, for four experiments, 2·652 lbs., while that consumed when steam was used in the same engine, doing exactly similar work, was as much as 5·626 lbs. You will see, therefore, that the consumption with the aqua-ammonia was considerably less than that with the steam. A sufficiently striking economy to justify further attempts in this direction, and further elaboration of the apparatus with which the economy was experimentally obtained.

* Diagram copied from Mr. Magovern's paper on "Aqua-ammonia Engines," published in the *Transactions of the American Society of Civil Engineers*, 1888.

Fig. 38 shows an indicator diagram taken from the engine when power was being obtained by the use of the ammonia gas. I would refer those of you who are interested, to the paper for full details of the experiments.

Fig. 38.—Indicator Diagram.*



The description of these experiments very appropriately leads up to the description of an apparatus, a sample of which I have here, which is being developed in this country by Messrs. Yarrow and Co., the torpedo boat builders, of Poplar.

An extremely interesting paper was read by Mr. Yarrow, on May 22nd, in this room, and the discussion upon this paper, and the paper itself are to be found in the *Journal* for May 24th.

In this engine Mr. Yarrow uses petroleum spirit, and, as I told you at the commencement of our lecture this evening, when we were considering petroleum engines, some of the petroleum products vaporise at a very low temperature.

If you can imagine an ordinary steam engine in which the water in the boiler and the steam in the steam engine are absent, but are replaced by petroleum spirit in the boiler, and by the vapour of this spirit in the engine, you can realise that which Mr. Yarrow does.

Instead of putting water into his boiler he puts in petroleum spirit. He puts a fire under the boiler, boils the petroleum spirit; petroleum vapour under pressure is generated; the vapour is taken to an ordinary engine; is there used in a way similar to that in which steam is used in the steam engine; the vapour on being exhausted from the engine—that is to say when it has done its work there—is condensed in a surface condenser, and is returned to the boiler for re-evaporation in a

* From Mr. Magovern's paper published in the *Transactions of the American Society of Civil Engineers*, 1888, taken with Tabor Indicator from a Porter-Allen engine, using ammonia gas in the cylinder.

manner absolutely similar to that adopted for steam in a condensing steam engine.

The comparative experiments which Mr. Yarrow has tried, give him a most satisfactory verification of the advantages which theory tells us should arise from the use of this petroleum spirit, in the way in which he uses it. He finds that if 9 represents the value of the work obtained from a given amount of heat put into the spirit or spirit vapour, 5 represents the value of the same amount of heat put into water or steam.

Incidental advantages which Mr. Yarrow obtains are, that the weight of his engine and boiler, and of the fuel he carries, for equal power developed, is very small as compared with that of a steam engine with its boiler full of water, and with the necessary fuel; further, for the purposes for which he is at present employing it (that of providing power for small yachts, launches, and such like boats, where it is of great use to be able to get under way rapidly), he has the advantage that a pressure of some 40 lbs. on the square inch is generated in the course of three or four minutes from the time of lighting up.

(To be continued.)

Miscellaneous.

THE VANILLA TRADE OF BORDEAUX.

One of the most delicate articles of trade upon the Bordeaux market is vanilla, which is imported into France from various countries producing this plant. Vanilla, says Consul Roosevelt of Bordeaux, belongs to the family of orchids, and was first found in the forests of Mexico. It is a plant furnished with thick oblong green leaves; the vine sometimes attains a height of 45 feet. The principal centre of production of vanilla is the littoral of Vera Cruz, and it is also found on the west slope of the Cordilleras, in Java, Mauritius, Seychelles, Tahiti, Cochin China, India, and in some of the islands of the West Indies. The vine in cultivation begins to bear the third year after planting, and continues to bear for 30 years. Each vine annually produces from 40 to 55 capsules or seed pods. The harvest commences in the month of April and lasts until June; the pods are gathered before arriving at complete maturity. There are two different methods in vogue for preparing vanilla for the market. The first consists in harvesting the capsules after they have lost their green tint. Woollen sheets are spread upon the ground, and when thoroughly heated by the sun, the pods are spread upon the sheets and exposed to the sun for a certain period. The pods are then put into boxes covered by a cloth, and again exposed to the sun. The fruit should become a coffee colour 12 or 15 hours after this last exposure. If, however, this colour is not obtained, the vanilla is again submitted to the heat of the sun. This process occupies about two months, at the expiration of which the vanilla is packed in tin boxes containing about 50 pods each, and securely packed. The second process consists in tying together about a thousand pods, and plunging them into boiling water to bleach them, after which they are exposed to the sun for several hours, and then coated with oil or wrapped in oil cotton to prevent the pod from bursting. During the drying, the pod exudes a sticky liquid which is expedited in flowing by gentle pressure of the pods two or three times a day. In preparing the capsule for market it loses about one quarter its original size. Vanilla is classified in four qualities. The pods of the *primeira*, or first quality, are from seven to nine inches in length, and proportionally large; they possess in greater abundance the characteristic and agreeable perfume which gives to the product its greatest value. The *chica punia* is less fine than the preceding. The *saccate* and *basura* are the smallest. The vanilla vine is at times covered with an efflorescence of a silvery brilliance, producing an essential salt similar to that found in the pod, and which is diffused on the outside of the capsule. This is called vanilla rime, and is in great demand on the Bordeaux market. The quantity of vanilla produced in the French colonies in 1886 was as follows:—Island of Réunion, 598,227 kilogrammes (kilogramme = 2·204 lbs. avoirdupois); Guadeloupe, 37,430 kilogrammes; St. Marie, Madagascar, 12,743 kilogrammes; Island of Mayotte, 5,461 kilogrammes; and Tahiti, 13,586 kilogrammes. Until 1845, the exportation of vanilla from the Island of Réunion was only about six or seven pounds annually, but by degrees the industry increased until at the present time, owing to the excellent quality and quantity produced, Réunion is an important rival and competitor with Mexico.

BEETROOT SUGAR INDUSTRY IN GERMANY.

A report has recently been issued by Baron Lucius on the subject of agricultural progress in Germany during the period 1884-87, containing some information respecting the beetroot sugar industry. Beetroot is one of the principal products of German agriculture, and Baron Lucius's work relates to the years during which the crisis in the German sugar industry was most acute. It was only in 1887 that its effects were less severely felt. It was, however, during the sugar year 1884-85—that is at the period at which the effects of the crisis were most disastrous—that the sugar industry used the largest quantity of beetroots. This may be accounted for

by the fact that all the preparations for the establishment of new factories, as well as for the extension of the cultivation of the beetroot, had been made before the sudden fall in the price of sugar. In 1884-85, in the German sugar industry—to which Prussia contributes to the extent of four-fifths—408 factories in full working were engaged; that is 32 more than in 1883-84, or 79 more than in 1877-78. The quantity of beetroot worked up increased during the same period in greater proportion than the number of factories; for example, it rose from 40,906,680 quintals (quintal = 220·4 lbs. avoirdupois) in 1877-78, to 104,026,883 quintals in 1884-85, and corresponded to the increase of cultivation. The quantity of sugar extracted from the roots rose from 3,805,091 quintals in 1874-77-78 to 4,467,303 quintals in 1884-85. Moreover, while in 1877-78, and in 1879-81 the production of a quintal of sugar necessitated the employment of 11·56 quintals of roots, this quantity waa reduced to 8·11 quintals in 1886-87, and under certain conditions fell even as low as 7·61 quintals in the sugar year 1887-88. The general adoption of the processes of diffusion, and the production of a beetroot richer in saccharine matter, materially contributed to this result, as well as the treatment of molasses, the production of which in special establishments, which was limited to 25,000 quintals of sugar in 1877-78, rose in 1886-87 to 381,000 quintals. On account of the crisis the manufacturers found themselves under the necessity of reducing the cost of production, and the reduction in the first places affected the purchase price of beetroots, which became less and less remunerative. The consumption of sugar in Germany is estimated at 8 kilogrammes per head of the population (kilogramme = 2·204 lbs. avoirdupois). The exports have increased in greater proportion than the production, and rose from 712,000 quintals of raw sugar and 223,000 quintals of refined in 1877-78, to 5,538,000 and 1,079,000 quintals respectively in 1884-85, and 4,897,000 and 1,542,000 quintals in 1886-87.

Correspondence.

OPEN-AIR SERICULTURE.

In a letter dated 10th of August, received to-day from my friend, Mr. John Griffitt, a member of the Society of Arts, and an eminent silk farmer near Smyrna, he relates some particulars connected with sericulture. On a former occasion I was enabled to send from the spot a report upon the silk harvest at Bournabat, near Smyrna, for 1885, which appeared at p. 852 of the *Journal* for that year. The season had been most favourable in every respect, and the troublesome worm diseases almost wholly got rid of by the farmers who followed Mr. Griffitt's advice, and used the regenerated Bournabat *graine*. The good report then given of the industry may now be repeated, with the addition that lessened anxiety on Mr. Griffitt's part has released him to engage in further investigations. One of these has been the interesting experimental attempt to rear silkworms on mulberry trees, under muslin screens, in the open air, an effort the success of which is all the more extraordinary when it is recollected what a delicate organism the average silkworm is, and how susceptible to cold, moisture, and the slightest sudden change of weather. The experiment may, very much in Mr. Griffitt's own language, be tabulated thus:—

1889.

April 18. Placed 300 worms, three days after their second moult, upon the leaves of a small mulberry tree, with a veil of tulle over them to protect the grubs from enemies.

,, 20. Hail, rain, and stormy wind prevailed all day, the temperature at 6 a.m. being as low as 45° Fahr.

,, 24. The worms successfully finished their third moult.

,, 25. Removed all the worms to a fresh mulberry tree.

,, 27. Again transferred them to pastures new.

,, 29. A wet day. It has rained more or less every day since the 20th.

,, 30. Once more removed the worms to other trees; all well.

May 5. The worms completed their fourth moult. On this occasion an enemy in the shape of a wasp obtained access, and ere the depredator was observed, destroyed six worms, but leaving the remainder uninjured.

,, 10. As rain again threatened, and the worms evinced signs of beginning to spin, in order to shelter them from the wet, they were removed into a room with a northern exposure, but with the windows all open.

,, 13. Mounting commenced, and the brushwood prepared was soon occupied, when spinning immediately began.

,, 20. Gathered the crop of 294 cocoons, 50 of which proved to be what the French call "Satiné" (satin-like).

June 9. The cocoons having been laid aside to mature, this day 294 moths issued from them, all robust and healthy.

July 15. A microscopical examination of the moths proved them to be entirely free from disease.

This, it will be acknowledged, was a most interesting and instructive experiment, and from it several important inferences may be drawn:—(1) That the regeneration of Mr. Griffitt's breeds of silkworms must have been thorough and complete to have enabled the 294 individuals to endure the low tem-

perature of 45 degrees, not to mention the storm and wet to which, for ten consecutive days, they were subjected; (2) that the proportion of fifty "satiné" cocoons is extraordinary as occurring in races which, when previously educated indoors, had scarcely ever exhibited this beautiful peculiarity; and (3) that it is but fair, from the result of experience, to conclude that, had this small hatching of silkworms been reared in a *magnanerie* in the usual way, and fed upon wet mulberry leaves, although not exposed to the changes of climate and temperature described, the whole would probably have perished by the fatal disease known as "flacherie."

This new departure in sericulture in Asia Minor, it is to be hoped, will lead to similar efforts in other silk-producing countries. Something of a kindred nature was tried in the Bombay Presidency with the *Antheræa paphia* some seven or eight years ago by Major Coussmaker, with entire success experimentally, although not with the most satisfactory financial results. He planted hedges of *Lagerstrœmia indica* and zizyphus seven feet asunder, with drains between, the intervening spaces being assigned to the cultivation of vegetables. At the hatching season, twelve-feet lengths of calico-covered screens were drawn over the ends of the hedges after the infant worms had been placed upon the young leaves. Gradually the little creatures ate their way along without interference or the necessity of being touched, and fairly secure against the attacks of insects, birds, or other foes, if watched by the attendants, who from time to time shifted bowers. In this manner, at short intervals, batch after batch of Tusser silkworms reached the end of their grazing promenade and began to spin. Although the hedge for some distance behind each detachment was left bare, the other extremity was green and ready for a fresh colony. The idea was admirable, but somehow the performance did not pay.

In Mr. Griffitt's case, however, there are elements of success which may have been absent in India. With his forty years' experience as a silk farmer, and rare scientific knowledge to boot, it will be surprising indeed if anything short of complete success attends this latest of his sericultural achievements.

WILLIAM COCHRAN.

Overdale-house, Dunblane, Perthshire, Scotland.
August 17th, 1889.

Notes on Books.

THE HISTORY OF AUSTRALIAN EXPLORATION FROM 1788 to 1888. Compiled from State documents, private papers, and the most authentic sources of information issued under the auspices of the Governments of the Australian Colonies. By Ernest Favenc. Sydney: 1888.

In 1788, Governor Phillip arrived in Botany Bay with the first fleet, and with this date Mr. Favenc commences his history of Australian exploration, but in an introduction he refers to previous visits to the continent. The earliest date in the author's chronological summary is 1503, when De Gonneville visited the South Seas. The French claim that he then touched on the coast of Australia, but the general belief is that De Gonneville landed on Madagascar. It was nearly a century and a-half after this that Tasman discovered Van Dieman's Land (now named after him Tasmania), and took possession of New Holland. In 1770 Captain Cook landed at Botany Bay and took possession of New South Wales. Mr. Favenc divides his subject into two parts—viz., land exploration and maritime exploration. The volume is illustrated with maps and fac-similes, one of the latter being of the curious Dauphin map in the British Museum, which is supposed to have been executed in the time of Francis I. of France for his son the Dauphin, afterwards Henri II. In this map the outlines of a large country south of Java are marked out.

SUBJECTS OF SOCIAL WELFARE. By the Right Hon. Sir Lyon Playfair, K.C.B., M.P., F.R.S. London: Cassell and Co. 1889.

In this volume Sir Lyon Playfair has collected together a number of articles and addresses on several points of importance for the social welfare, and these he has arranged under the three headings of Public Health, Industrial Wealth, and National Education. Among the subjects dealt with under Public Health are vaccination, vivisection, disposal of the dead, and sleep. The heading of Industrial Wealth includes papers on depression of agriculture and fair trade, displacement of labour by invention, industrial competition and commercial freedom, effect of protection on wages, bi-metallism, inosculation of the arts and sciences, science and the State, and petroleum the light of the poor. In the third part primary education, technical education, teaching universities and examining boards and universities, and professional education are dealt with.

PRACTICAL PHOTOMETRY: a Guide to the Study of the Measurements of Light. By William Joseph Dibdin. London: Walter King. 1889.

The object of the author has been to produce a practical guide to the use of the photometer, and he points out in his introduction how many of the difficulties which occur to the photometrist may be met by reference to the different chapters, and some help given as to the kind of instrument that should be chosen for various purposes. The uncertainty as to the standard of light is remarked on, and the author expresses the opinion that this uncertainty cannot long be maintained. He notes that the

annual value in London of a "candle," in the illuminating power of "sixteen candle gas," is in round numbers £200,000. The author's first chapter is devoted to the history of photometry, commencing with François Marie's obscuration method in 1700, and leading up to Bunsen's greased spot photometer, which induced the late Emperor Frederick of Germany, then Crown Prince, to say, when it was shown to him, that for the first time in his life he learnt the value of a spot of grease, and Mr. Vernon-Harcourt's pentane air-gas, introduced in 1877, as the substitute for candles as a standard. Special chapters are devoted to horizontal and radial photometers, to colour photometry, and to stellar photometry.

WAR WITH CRIME, being a Selection of Reprinted Papers on Crime, Reformation, &c. By the late T. Barwick Ll. Baker. Edited by Herbert Philips and Edmund Verney. London: Longmans. 1889.

Mr. Baker, who died at Hardwicke Court, Gloucester, on December 10th, 1886, left behind him the result of a life's labour in the practical study of the criminal classes. The editors state in their introduction that their aim "has been to reprint in an accessible form the chief papers dealing with problems still unsolved, that we may learn the leading principles which actuated him in seeking their solution, and to see to it that we ourselves approach them in a spirit not less noble and unselfish." The papers are arranged under the following twelve headings—1. Prevention of Crime; 2. Systematic Sentenctng of Prisoners; 3. Police Supervision; 4. Adult Reformatories; 5. Imprisonment of Children; 6. Gaol Labour; 7. Reformatories; 8. Vagrancy; 9. Ecclesiastical (Church Conferences, Public Worship Bill); 10. Education; 11. Labour and Wages; 12. Prison Government. The book contains a memoir of Mr. Baker and a portrait, taken from a drawing by G. Richmond, R.A.

THE USEFUL NATIVE PLANTS of AUSTRALIA (including Tasmania). By J. H. Maiden, F.L.S. London: Trübner. 1889.

This book has grown out of a catalogue of the specimens of plants indigenous to Australia in the Technological Museum of New South Wales by the Curator. The various plants are classified under ten headings of Human Foods and Food Adjuncts, Forage Plants, Drugs, Gums, Resins and Kinos, Oils, Perfumes, Dyes, Tans, Timbers, and Fibres, and there are indexes of vernacular and botanical names. The author states that the literature of Australian economic vegetable products may be said to date from the Great Exhibition of 1851, and that the present is the first book covering the whole of the subjects to which it refers.

THE USES OF PLANTS: a Manual of Economic Botany, with special reference to Vegetable Products introduced during the last fifty years. By G. S. Boulger, F.L.S. London: Roper and Drowley. 1889.

The author claims that from the first writings of the herbalists of the 17th century down to the present day, the chief votaries of botanical science have never allowed the claim of pure science to divert their attention from the practical application of their studies to the wants of their fellow men. After an account of the progress of economic botany in England during the fifty years from 1837 to 1887, Mr. Boulger describes the various plants under foods, food stuffs, and food adjuncts, materia medica, oils and oil seeds, gums, resins, &c., dyes and tanning materials, fibres and paper materials, timber and other woods, and agricultural plants.

Obituary.

JOHN GREGORY CRACE.—Mr. Crace, who died on the 13th inst., at his residence, Springfield, Dulwich, was for many years an active member of the Society of Arts. On January 27th, 1858, he read a paper on "The Use of the Soulages Collection of Italian Art in Modern Art Manufacture," when numerous specimens from the collection were exhibited. Four years later he read a paper on "The Decoration of the International Exhibition Building," a work upon which he was then engaged. In 1866 he read a paper on "Old London: its streets and thoroughfares," the information in which was grounded on the fine collection of London views originally formed by Mr. Crace's father, and now in the British Museum. Mr. Crace was born in 1809, the fourth in descent of a race of artistic decorators. His father, Frederick Crace, was the son of John Crace, who was born in 1754. John Crace's father (Edward) decorated the Pantheon in Oxford-street in 1771, and in 1780 was appointed by the Crown Curator of the pictures in the Royal Palaces. Mr. J. G. Crace was selected by Government, in 1848, to execute the coloured decoration of the new Houses of Parliament. He was largely employed at the Exhibition of 1851, and designed the decorations for the Art Treasures Exhibition at Manchester, in 1857. In 1861 he was employed in the decoration of the Waterloo Chamber at Windsor Castle. In the following year he was engaged on the Exhibition of 1862, already referred to. He decorated the Society's meeting-room, when it was last repaired, in 1882, as he had done on previous occasions.

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FRIDAY, AUGUST 30, 1889.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

ART-WORKMANSHIP PRIZES.

The Society of Arts offer the sum of £150 in money prizes, as well as twenty of the Society's Bronze Medals, for objects in the Arts and Crafts Exhibition to be held in the autumn of the present year. The judges will be empowered to distribute the money, or such proportion of it as they see fit, in any sums they think will best meet the relative merits of the exhibits, at the same time paying due regard to the cost of production. The whole sum will only be expended in case of works of sufficient merit being forthcoming.

It will be understood that the Arts and Crafts Exhibition Society do not undertake responsibility in respect of the awards of the prizes, which will be a matter solely under the control of the Society of Arts.

The rules under which the prizes will be offered are substantially the same as those under which the previous art-workmanship competitions of the Society have been carried out.

The Exhibition of the Arts and Crafts Exhibition Society will open at the New Gallery, Regent-street, on Monday, October 7th, and will close on December 7th.

The following is the classification of the objects to be received for exhibition, as put forth by the Arts and Crafts Society :—

(a) Designs and cartoons for decoration of all kinds.
(b) Decorative painting—more particularly in association with architecture or cabinet work.
(c) Textiles—Tapestry, Needlework, woven and printed patterned Fabrics, Lace.
(d) Painted glass.
(e) Pottery—Tiles, Majolica, painted China.
(f) Table glass.
(g) Metal work—Wrought iron, brass and copper Repoussé, Gold and Silversmith's work and Chasing.
(h) Wood-carving } Carving in ivory and
(i) Stone-carving } other materials.
(j) Cabinet work—inlaid, and painted and carved furniture.
(k) Decorative Sculpture and Modelled Work—Friezes, architectural enrichments, relievos, plaster and gesso work, &c.
(l) Printing—Book decoration, Printers' ornaments, Illuminations and decorative MSS. Wood and metal engraving.
(m) Book-binding and cloth-cases.
(n) Wall papers.
(o) Stencilling.
(p) Leather work—Stamped, tooled, cuir-bouilli, &c.

And such other kinds of decorative Art not above enumerated as may be approved by the Selection Committee.

Information respecting the Exhibition and forms of application may be obtained from Mr. Ernest Radford, Secretary of the Arts and Crafts Exhibition Society, at the office, 44, Great Marlborough-street, London, W.

Proceedings of the Society.

CANTOR LECTURES.

HEAT ENGINES OTHER THAN STEAM.

By H. Graham Harris, M.Inst.C.E.

Lecture IV.—Delivered May 27th, 1889.

(Continued from p. 771.)

You will remember in our first lecture, when defining heat engines, I told you that a cold-producing apparatus was commonly a heat engine. In those various forms of apparatus in which refrigerating is done by compressed air—that is to say, in those forms of apparatus manufactured by the Haslam Company, Messrs. Hall, and others—there is no doubt that the conversion of the heat of

the steam into the "cold" in the "cold room" is done by means of a heat engine. That is to say, we have first the conversion of the heat of the fuel into the heat of the steam in the steam boiler, then the conversion of the heat of the steam into work done in compressing air in the compressing pumps, the temperature of the air being raised during this compression by the work put into it, as I have on two or three occasions during these lectures pointed out to you it would be; then the reduction of that temperature of the air, first by cooling water, and then further by the conversion of some of the heat into work by expanding the air behind a moving piston in a cylinder, the work so produced being utilised to aid in compressing the incoming charge of air.

This is one of the commonest forms of refrigerating machines, one which is now-a-days almost invariably used in the trade of bringing frozen meat from our colonies. The practical difficulties in connection with it are those due to the deposition and solidification, in the form of snow or ice, of the moisture of the air cooled in the machine.

Many other forms of apparatus have been designed for refrigerating purposes, these using other materials or bodies than air, the necessity for refrigeration in these days being a pronounced one.

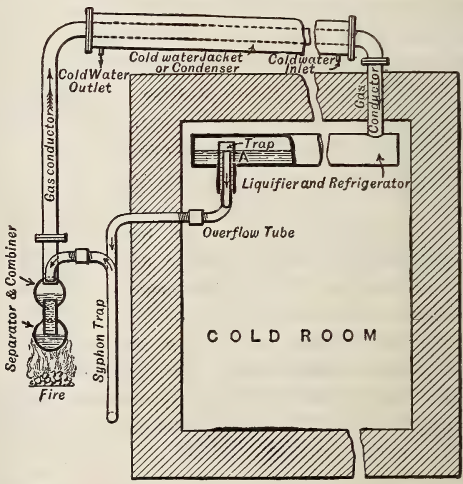
Let us now consider this refrigerator which I have here, designed by Mr. Loftus Perkins, a name so long associated with all that is advanced, all that is most progressive in the conversion of heat into mechanical work.

Here we have an apparatus which does not contain within it any moving part of any sort or kind; in which, in order to obtain from it the greatest effect that it is capable of giving, all that is required is that the fire should be lit, or the gas should be lit, at regular stated intervals; should be allowed to burn for a definite time; and then that water should be run over this portion of the apparatus, in order to liquefy the vapour that has been generated by the heat of the fire.

The liquid employed by Mr. Perkins in this apparatus is, as I have said, the same as that used in the experiments recorded in Mr. Magovern's paper, to which I have referred, viz., aqua-ammonia. As I told you, the temperature at which this liquid will give off the ammonia gas held in solution in it depends entirely upon the specific gravity of the solution, but it is always low as compared with that necessary to obtain equal pressures by the vaporisation of water. If the solution contains a large quantity of ammonia gas, then the temperature necessary, in order to liberate the greater portion of it, is less than that necessary when the quantity of ammonia gas is small; but, in any case, a temperature of about 260° Fahr. is sufficient to liberate practically all the ammonia gas from a solution of such strength as Mr. Perkins uses, leaving the water alone. Pure anhydrous ammonia, in the form of gas, will liquefy, *i.e.*, will change from the state of gas to that of liquid, still remaining as anhydrous ammonia, *i.e.*, ammonia without water, at temperatures varying entirely with the pressure existing in the apparatus in which the aqua-ammonia is confined. But, at the ordinary pressure of the atmosphere, pure anhydrous ammonia will liquefy at a temperature of about −32° Fahr., there or thereabouts; while under a partial vacuum of some 20 to 25 inches the temperature of liquefaction of the ammonia will, of course, be considerably less.

Now Mr. Perkins puts into a series of hermetically closed tubes (see Fig. 39), a definite

FIG. 39.—"ARKTOS."



quantity of liquid aqua-ammonia, the strength and quantity of the solution depending upon the capacity of the apparatus, and the purpose for which the apparatus is required. Before hermetically closing the apparatus heat is applied, so that ammonia gas is generated in it, and the atmospheric air is driven out. The apparatus is then sealed up while hot, with the result that, when it is cool, the ammonia gas re-combines with the water, and there is a vacuum equal to some 20 to 25 inches of

mercury (10 to 12 lbs. on the square inch) in it. The liquid aqua-ammonia is, at the commencement of a cooling operation, in the pipes at the lowest portion of the apparatus where the fire is shown, these pipes being marked "separator and combiner."

Now when a fire is placed under the separators and combiners, the ammonia gas is liberated from the water, a pressure of ammonia vapour is generated throughout the whole apparatus, and cooling water being passed through the horizontal jacketted pipe at the top, termed the "condenser," when the pressure is sufficiently high, depending on the temperature of the cooling water, the gas will be liquefied, and will, owing to the slope of the pipe forming the condenser, pass away, as liquid anhydrous ammonia, through it into the cooling pipes—called in the diagram the "liquifier" and "refrigerator"—which are shown at the top of the cold room.

Now, when the fire is withdrawn from under the combiners, all the gas having been driven off from solution, the pressure will fall, and the liquid ammonia which is in the cooling pipes will no longer remain as liquid, but will vaporise (the temperature at which this vaporisation takes place depending, as I have told you, upon the pressure), seizing the heat necessary for this vaporisation from the pipes in which it is contained, these taking it from the vessel containing them, and thus heat will be abstracted from the cold room, and from its contents, or from the vessel, whatever it may be, containing these cooling pipes. You will remember I have told you that the latent heat of vaporisation of the pure liquid anhydrous ammonia is 895 units. Each pound weight of it in vaporising must, therefore, if it is pure, abstract from the pipes or the cold room in which these are contained, or must obtain from somewhere this number of heat units.

As the liquid anhydrous ammonia vaporises, it will pass over into the combiners, and will re-combine with the water there; the pressure in the apparatus will become normal as the recombination is completed; or, as the apparatus is generally arranged, a vacuum will be formed; and before a further abstraction of heat from the cold room can be obtained, a re-heating, *i.e.*, a fresh vaporisation and subsequent liquefaction and re-vaporisation of the anhydrous ammonia will be necessary.

To the left of the diagram, at the bottom, you will see the bent pipe forming a syphon trap by which the small quantity of water vapour, which is condensed and passes over into the cooling pipes, is automatically returned to the separators and combiners.

Here, then, we have an instance of a heat engine wherein, as I have said, there are no moving parts of any sort or kind. Mr. Perkins points out that with it the ordinary English cook of the ordinary English household can do all the freezing or cooling required, by simply lighting the fire or the gas, by turning this out when needed, and then by turning on the water and allowing it to run for the purposes of condensation. With such an apparatus as this, the most intense cold can be produced. That is to say, temperatures in the cooling pipes of $-60°$ Fahr., or, say, $92°$ below freezing point are readily produced.

I do not mean to suggest for one moment that the principle involved in this apparatus is one which is new. M. Carré, a Frenchman, many years ago constructed a somewhat similar machine based upon the same principle, and there are many ammonia freezing machines in the market. All of them, however, require cocks or valves in them, or have moving machinery of some sort or kind in connection with them in order that they shall do their work; or (as in one apparatus by M. Carré) have to be completely turned over after heating, so as to bring the liquid again to the place for reheating. They are all, therefore, to that extent, inferior to this apparatus, which is entirely self-contained, and is entirely automatic, needing only the very smallest amount of attention, such as I have described above.

Mr. Perkins has been good enough to put an "Arktos" to work—a small one—in this room. It is heated by a gas burner, and the water for condensation is supplied from the water company's mains. It is only a sample apparatus, and he does not profess that this particular "Arktos" as it is here arranged is, in any way economical in its production of cold, that is to say, the quantity of gas for heating, and of water for cooling, used with it are higher than they need be.

You will see, or rather you may take it from me, that the temperature of the room, according to the thermometer hanging here is at present about $78°$ Fahr., and you will see that there is frozen in this temperature a solid piece of mercury, frozen so hard that it can be cut with a knife, and can be passed round the room.

When I remind you that the freezing point

of mercury is $-38°$ Fahr., or equal to $70°$ below freezing point, and when I tell you that the reading of this other thermometer, placed as it is in the cooling pipe of the apparatus, is nearly $-60°$, *i.e.*, $92°$ below freezing point, you will realise the perfection which Mr. Perkins has attained by careful attention to the proportioning of the various parts of his apparatus, and to the strength of the solution contained in it.

I do not want to labour the description of this, or to spend too much time upon it; but I may tell you that I have seen a room, ten feet square and seven feet high, *i.e.*, having a capacity of 700 cubic feet, which is in ordinary use by a poulterer, who is putting into it and taking out of it meat and poultry of all sorts and kinds, to suit the exigencies of his business, kept at a temperature for weeks together never exceeding $15°$ Fahr., equal to, say, $17°$ below freezing point, and this with an expenditure of fuel and of water equal to a cost for each of, from, 1s. to 1s. 3d. per day, the apparatus requiring only the attention of a lad twice during every twenty-four hours for about two hours on each occasion, to maintain this low temperature—and I think you will agree with me that, for the particular purpose for which it was designed, this apparatus is one which has attained a large measure of success.

The only objection which I have heard against it is that the aqua-ammonia of commerce, which is impure, will seriously affect the iron or steel of which the tubes are composed. Mr. Perkins, however, assures me that this is a fallacy in respect to the aqua-ammonia he uses, and as a proof of his statement, he produces a portion of an "Arktos" apparatus which he has had continuously in work for over six months, and which has, therefore, for the whole of that time been subjected to the evil effect, if any, of the aqua-ammonia. But, as you will find (those of you who care to examine it after the lecture), this pipe appears to be absolutely unaffected or uninjured. Further than that, I am told, on most excellent authority, that there is no chemical reason why an hermetically sealed apparatus, as this is, containing aqua-ammonia, should be in any way injuriously affected.

There is one other form of heat engine to which I must refer before I close that which I have to say. It is one which has at intervals attracted the attention of very able men, and it is one to which, as Colonel Gouraud informs me, Mr. Edison himself is devoting much time and consideration. What its possibilities are we cannot at present say. It is that form of apparatus where heat is directly converted into electric energy.

Now of heat we think we know something; of electricity, and what can and cannot be done with and by it, I am sure we know very little. That electricity is convertible, as heat is, into motion, we are certain, from the many experiments which have been tried, and from the results which have been obtained. That heat and motion are convertible I trust I have proved to you; but, without attempting in any way to define or even consider the question, "What is electricity?" I will only ask you, those of you who are not already aware of it, to take it from me as proved, that heat can be directly converted into electric energy, and electric energy into heat. If we could produce electric energy directly from coal—that is to say, if we could convert the heat units of the coal directly into electric units by means of some simple transforming apparatus, and if we could do this with reasonable economy—there is no doubt we should have made another of those great steps of progress for which I venture to think the 19th century will in the future be noted.

Many able men have been attracted in the past by the possibilities of this conversion, and some of our ablest men are now considering it. The whole point of the greatest practical success which has, up to the present, been attained, is based on the fact that the capability of magnetisation of all the metals which are easily magnetisable is affected, is very largely affected, by the temperature existing in the metal when magnetisation takes place. Iron entirely loses its capability of magnetisation when it reaches a cherry-red heat, while at ordinary temperatures, as we know, it is capable of a high degree of magnetisation.

It is in this direction that Mr. Edison is working, and his ideas are, at present, to devise some apparatus from which power shall be directly obtained by variations in the magnetisation of some metal, such as iron, these variations being due to rapid changes in the temperature.

In the ordinary thermopile we know that the electricity produced depends entirely upon the relative heat of the bodies composing the magnetic couple.

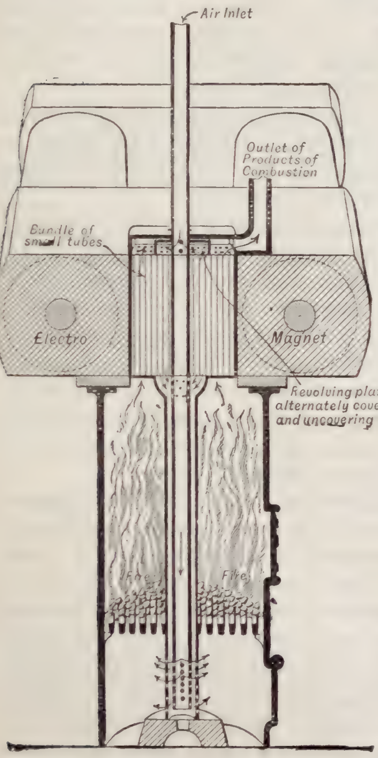
You will realise that to some extent we have in such an electric heat engine as Mr. Edison has devised (one where power is obtained from the variation of capability of magnetisation of a metal dependent on the temperature of that metal) the

Carnot theory involved, *i.e.*, incoming temperature is represented by the low temperature of the metal, or by its capability of magnetisation; outgoing temperature is represented by the hotter metal, and, therefore, by its want of capability of magnetisation—the Carnot engine reversed.

Very little has been practically done in this direction by Mr. Edison; no results of any note are, as yet, public property; but I am informed that he has great hopes of success, based on the results of elaborate experiments he has made; and I am further told he is, as I have already said, devoting much time and attention to this particular matter.

You will find among the prints which you have (Fig. 40) one showing his pyro-magnetic motor, a description of which he published some two years since.

FIG 40.—EDISON'S PYRO MAGNETIC DYNAMO.



There is at the top of the apparatus a permanent magnet, with its two arms or poles, between which is placed a bundle of small tubes made of thin iron, and capable of rotation on an axis at right angles to the plane of the magnet, in a manner similar to that in which the armature of a dynamo revolves. These tubes are open at their bottom ends to the fire burning below them. There is, on the top of the tubes, a screen, or plate, covering, as the tubes revolve, one half of them at a time. Thus the products of combustion can pass through one half (being prevented by the plate from passing through the other), and thus one half of the tubes will be heated, the other half being at a lower temperature. This was the first suggestion. But still better results were obtained when the fresh air needed for combustion was passed down through those of the tubes which were being kept cool, this air, when heated and mixed with the products of combustion, being allowed to pass away through the other half of the tubes when they are to be kept hot, as shown in Fig. 40; thus introducing the principle of the regenerator of Stirling, described in our second lecture, and deriving some of the advantages to be obtained from its use.

Now if iron has, as I have said, a different capability of magnetisation, depending upon whether it is hot or cold, there should be in that portion of this bundle of tubes which is hot, a different degree of capability of magnetisation from that existing in the portion which is cold, and these tubes being so arranged as to be able to rotate, and being placed between the poles of a magnet, rotation should be set up, that is to say, the attraction of one pole and the repulsion of the other should revolve the bundle of tubes; and in this way power should be obtained.

According to Mr. Edison, he had, when he published his paper in 1887, a motor on this principle in course of construction, from which he hoped to produce about 3 horse-power.

He had already constructed one giving as much as 700 foot-pounds per minute, that is to say, equal to a little more than 1-50th of a horse-power.

As I have said, what the probabilities of economical success are with such an apparatus it is impossible, as yet, to predict. We, at present, are only sufficiently "ignorant" to enable us to realise that there may be economical possibilities in this form of heat engine, which we can only imagine.

I believe I have now spoken of all the various forms of heat engines which I think it necessary to describe as being germane to, or illustrative of, the particular subject which it has

been our business to consider. I should like to enlarge upon the thermo-electric motor, and to point out how even in it the Carnot theory of efficiency is exemplified, but time and the "clock" are inexorable, and I must conclude.

You will remember that I commenced with a text—a text containing a prophecy. When that prophecy was made, without having considered the subject to anything like the extent I have had since to consider it—in order to prepare these lectures — it seemed to me that the prophecy was rash.

Let us just recapitulate, as briefly as possible, the heads of that which we—I trust all of us—agree we have found to be proved, both theoretically and practically.

In hot-air engines—using the term in its popular sense—theory tells us there should be possibilities of economy largely in excess of those to be found in the steam engine; but so far practice has not fulfilled the teachings of theory, and practical difficulties arise, of such a character that we do not see how they are to be successfully overcome.

In gas engines the steam engine already has a formidable, and for small powers, a successful rival. Theory, however, tells us that this rivalry should be still more favourable to the gas engine, and practical considerations do not at present appear to have put a limit to advance and progress, saying "Thus far shalt thou go, and no farther." This is the present state of the rivalry with gas engines when used for small powers, and the practical limitations in the way of increase to large powers, do not appear to be such as should prevent further development, by which further economy will be obtained.

In petroleum engines, with the increase in the production of petroleum itself, with the probability there is that the use of lighting gas from coal in its present form has, in many places, reached its highest development, what the possibilities are it is as yet difficult to say; but that they are at least equal to those of the gas engine is certain, and the practical considerations which I have just suggested may cause those possibilities to have greater force in the immediate future, with the result that the development of this form of engine is almost certain to be rapid.

Further than this, as our knowledge increases, as the needs of civilisation increase, and as our stock of coal becomes of more and more value to us, owing to its diminution, is it not almost certain that greater further efforts will be made to develop the petroleum industry in this direction? I trust you will agree with me that I have proved to you that theory shows us these efforts should be successful, and that by such engines also the prophecy of our text will be fulfilled.

What to expect from electricity and from Mr. Edison, and others who are working in the same direction, I cannot even suggest; but he and they have conquered great difficulties in the past, and it is probable that he or someone else will conquer the equally great difficulties which exist in the practical development of the production of electric energy directly from heat, and that this will be done in the very near future.

I trust I have now made it clear to you that the steam engine has much to fear from its powerful rivals already in existence, and that the prospect of progress is in a direction in favour of these rivals, *i.e.*, in favour of "heat engines other than steam;" that, therefore, I was justified in saying the prophecy of the President of the British Association was unique among modern prophecies, for it is almost certain of fulfilment.

It now only remains for me to thank you for the courtesy and attention with which you have listened to me, and for the patience which you have displayed.

The mass of matter which is legitimately covered by the title of these lectures, "Heat Engines other than Steam," seemed to me (when I came to completely investigate it) such as to render it almost impossible to give, in the short time at our disposal, a connected and sufficiently clear and explicit outline (for it could not possibly be more than an outline), of the theory and practice of working and construction of such machines.

I trust, however, I have succeeded in preserving the outline sufficiently clear, and I trust I have succeeded in interesting you; if I have, or if I have suggested new ideas to the many practical workers who have honoured me with their presence, I shall be doubly rewarded, because I shall have the satisfaction arising from this reflection, in addition to the pleasure which I have derived from preparing and delivering these lectures—a pleasure which has been largely increased by your courteous and encouraging attention.

In concluding, I must ask you to join with me in thanking the many gentlemen who have lent me models, apparatus, and diagrams, and have thus assisted me in interesting you in this subject.

Miscellaneous.

OLIVE CULTIVATION.

By P. L. Simmonds.

Of the various food products, or vegetable liquids, perhaps those most extensively shown at the Paris Exhibition are wine and oil. These two seem to follow the progress of civilisation and settlement, whenever the climate is suitable. Olive oil is shown in a very large number of the foreign sections, and the wide and extensive progress it has made over the world is exemplified now by one French exhibitor, who exhibits samples from the following widely-separated districts:—The Gold Coast of Africa, Melbourne and Adelaide, Chili, Guatemala, Guayaquil, Mexico, Venezuela, La Plata, New Orleans, Philadelphia and New York, Canada, India, Cochin China, Reunion, Mauritius, Japan, Polynesia, Havana, Guadaloupe, Martinique, Trinidad, Haiti, the Black Sea Coast, the Levant, Spain, Portugal, and France.

But these are not all the seats of production, and are merely cited to show how widespread is the culture of the olive at the present day.

Taking the French official catalogue, and turning to the alimentary products, "class 69, oils and fatty substances," there will be found over 600 exhibitors of olive oil specially named, besides numerous collective exhibits, and many others also are included under the general term "comestible" or edible oils. There is much substitution, however, carried on in this respect at the present day by the sale to the public of refined cotton-seed oil, sesame, and other oils, in place of olive oil. The number of exhibitors of olive oil under each country are as follows:—

Portugal	448
Algeria	128
Italy	8
France	12
Spain	5
California	4
Japan	1
	606

There are two or three exhibitors also from Tunis, and in the French section there is a collective exhibit of edible oils made by 67 producers and dealers from Salon, Bouches du Rhone.

The various uses of the olive for its fruit and its oil are well known. In ancient Greece the tree received all the honours, and had almost a sacred character. This was in consequence of its being the chief production of the country, and its produce the main source of public food.

From olden times the people of the Mediterranean coasts have made the olive their principal culture, and it is there the oil industry chiefly centres—in Spain, Portugal, Italy, Greece, and France, on the northern coast; and Morocco, Algeria, and Tunis, on the southern shores.

The olive has been cultivated in those regions from time immemorial, as the bounteous gift of Heaven and the emblem of peace and plenty. Olive oil takes there the place of butter. Spain has about 3,000,000 acres under olives, Italy 2,250,000, and France about 330,000, of which 15,000 acres are in the district of Nice. Olive oil in the country of Nice forms now four-fifths of the agricultural produce.

The varieties of the olive are very numerous. The naturalist Risso, in 1826, described forty distinct varieties, and these have since been increased to forty-five.

In the countries where it is indigenous, the olive tree attains gigantic proportions. It reaches, occasionally, 60 feet high, with a circumference of trunk of 12 feet, and these trees are supposed to have attained an age of 1,000 years. Certain varieties grow more rapidly than others, and some differ from each other in the nature of the wood, the foliage, and the quality of the fruit. There are large olives and small olives, pointed, oval, round, and curved fruit, and of all colours, ranging from white to black, and from green to red. The flavour of the fruit is mild, sharp, or bitter. Hence, according to the variety, there is obtained sweet oil, light coloured, and of exquisite flavour, up to dark green, thick, and of a bitter taste, strong and very unpleasant to the palate. Hence it follows that olive oil can be obtained pure, and also quite unfit for food purposes, only suitable for greasing machines and making soap. The green unripe olives, after remaining in a solution of salt for some time, to remove the bitter taste, are preserved in vinegar, with spices, in bottles or small barrels. Those of Tuscany and Lucca are considered the best, on account of their light-green colour and strong flesh.

In all parts of Southern Europe they are in this form a daily food. The ripe olives are gathered in the fall, when they are as large as common plums; their colour is dark green, and the soft kernel has changed into a hard stone, which contains a savoury almond. The flesh is spongy, and its little cells are filled with the mild oil, which pours out at the least pressure.

There is a fine collection of preserved olives shown by Hernanos and Co., of Barcelona. The finest oil is the so-called virgin oil, to obtain which the freshly gathered olives are put into little heaps, and by their own weight the oil is pressed out, and is caught in some vessel. It is clear like water, has a delicate nut-like taste, with little or no odour. When the fruits cease to give the oil by themselves, they are pressed with small milkstones. The oil gained by this process is also clear, and of a pleasant taste.

After this treatment the olives are still rich in oil, and the fruits are put in sacks; boiling water is poured over them, and they are pressed once more.

The oil gained by this process is yellowish green, and has a sharp taste and an unpleasant smell, because it contains some mucilaginous matters.

At Marseilles, the great seat of the vegetable oil trade, the olive oils are classed into manufacturing oils for burning, for greasing machinery in factories, and for soap-making; refined oil; oil from the pulp or husks; and table or edible oil. The latter is divided into superfine, fine, half-fine, and ordinary. The table oil is refined by allowing it to run through layers of thin sheets of wadding into tin perforated boxes; the wadding absorbs all the thick particles, and leaves the oil perfectly clear and tasteless.

In the Spanish Section, Signor Jose Gonzalo Priete, who has steam works at Lora del Rio, Seville, makes a display of an imitation olive tree silvered, from the branches of which are suspended six glass globes, filled with the different qualities of pure olive oil.

The imports of olive oil into the United Kingdom have been falling off of late years. The quantity received in 1888 was only 18,535 tuns, against 21,000 to 24,000 tuns in the previous years. The value of the imports was £672,614. The bulk of the supply came from Italy, Turkey, and France.

The Tuscans were the first who exported olive oil largely, and thus it has obtained the name of Florence oil. It would be a curious fact to ascertain the number of olive trees which exist in the different countries bordering on the Mediterranean—Tunis has over 4,000,000, Algeria 3,000,000, Nice 1,000,000, Syria several millions, while the number in Spain, Portugal, Italy, Greece, Morocco, and Turkey are unknown.

The Union of Proprietors of Nice is a limited society, with a capital of £20,000, which, by its statistics, binds itself to deal only in pure olive oil. It has about 26 plantations and presses in different parts of the district. The company makes a fine display of olive oil.

It may be stated, in conclusion, that the olive crop is a very variable and uncertain one; one that yields a profit does not perhaps occur for six or eight years.

REPORT OF THE COMMISSIONERS FOR THE EXHIBITION OF 1851.

The Commissioners have just issued their seventh report, which brings the account of their proceedings down to the present time. The number of institutions now standing on the estate of the Commissioners is as follows:—

1. The South Kensington Museum, the Schools of Science, and the Department of Science and Art.
2. The Natural History Museum.
3. The India Museum.
4. The Patent Museum.
5. The Museum of Scientific Instruments.
6. The Royal Albert Hall.
7. The Central Technical Institution.
8. The Royal College of Music.
9. The Imperial Institute.
10. The Royal School of Art-Needlework.
11. The Alexandra Home for Female Students.
12. The Museum of Fish Culture.
13. The Anthropological Laboratory.
14. The School of Art Wood-carving.
15. The Home Arts and Industries Association.
16. The School of Cookery (*now removing*).

The Commissioners give the following account of the amount of their contributions to public purposes.

"In our last report we mentioned that the result of the Exhibition of 1851 left us in possession of a sum of £186,000, and we showed that the continual increase in the value of our estate had already enabled us to contribute to public purposes money and property amounting to nearly half a million. We have since the date of that report allotted, as above reported, for the Central Technical Institution a site valued at £40,000; to the Alexandra Homes a site valued at £10,000; to the Royal College of Music a site valued at £45,000; and to the Imperial Institute a site the value of which cannot be estimated at less than £250,000. In addition to these grants of land, we have by our annual subscription of £500 a year to the Royal College of Music, provided a sum of £3,000 for musical education."

The conclusions of the report are thus summarised.

"We have mentioned the non-acceptance by her Majesty's Government of our offer to provide a building for a Museum of Science, and the steps which we have subsequently taken in the hope of inducing the Government to establish on our estate those institutions ancillary to the teaching of science which are necessary to form a complete system of scientific education for this metropolis. We have referred to the circumstances which compelled us to put an end to the connection between the Royal Horticultural Society and our estate, and have narrated the steps taken to recover possession of the gardens from the society, and the uses to which that portion of the estate has been subsequently put. We have given detailed accounts of the establishment on our estate, since our last report, of the Central Technical Institution, the Royal College of Music, the Alexandra Homes, and the Imperial Institute, and have also explained the relations which have existed between us and the various bodies accommodated on our estate. We have reported the various other dealings with the estate since the date of our last report, and have submitted statements showing our financial position. We have also submitted our proposals for the future, which are in effect the raising of a considerable free income by allotting for private building purposes part of the northern portion of the central quadrangle of our estate, while reserving in our hands sufficient space for the development of the Science and Art Department, and the founda-

tion, from part of the surplus income thus obtained, of scholarships for the purpose of assisting provincial technical institutions of science and art, and connecting them, if they desire it, with the larger schools and colleges which exist in the metropolis.

"The experience of recent years has convinced us that a substantial disposable income will enable us to work more usefully in this and other directions for the public benefit than would the mere ownership of unproductive land. While we have always kept in view the original objects of our trust, the remarkable increase in the value of the estate which was secured to us by the wise forethought of his Royal Highness the Prince Consort, our first president, has enabled us to give a wider scope to our work than could have been anticipated from the amount of the fund which the success of the Exhibition of 1851 placed in our hands. The profits of that Exhibition were derived from national and not simply metropolitan co-operation, and we believe that we carry out the wishes of its royal founder when we propose to realise part of our property for national purposes."

INDUSTRIAL ART IN THE LOIRE.

The United States Consul at St. Etienne, in his last report, says that a society was then being formed there under the name of "Société d'Art et d'Industrie de la Loire," with a view to developing the commerce and industry of the department of the Loire, and furnishing its artisans with the means of extending their instruction in the trade to which they may belong. For this purpose the society is to establish at St. Etienne a combined museum and library containing works of industrial art, models (either original or in the shape of reproductions), drawings, engravings, photographs, and books, all of which articles will be selected with exclusive reference to the existing industries of the department. Annexed to the library museum will be a bureau of commercial information, in which will be found for the use of merchants and manufacturers such documents, foreign as well as French, as may be of interest to them. It will also contain all information sent by consular agents to the French Ministry of Foreign Affairs, and by French Chambers of Commerce established in foreign countries, &c. The society will further establish a bureau of industrial consultation where the members will receive advice as to the improvement of their looms and other machinery, and where also such plans, models, and designs as may be submitted to the society will be corrected free of expense. The head-quarters of the Society are to be at St. Etienne. Branch societies will be established at the centres of population of the department, as at Roanne, Montbrison, St. Chamond, &c., and through these branch societies application for books and models from the library museum at St. Etienne will be made. As regards the organisation of the society, in the department of the Loire two artistic branches of the Loire predominate, that of the ribbon trimmings (*rubanerie passementerie*) and that of arms; these constitute the two first sections of the museum. The ribbon trimming section, in the division of patterns, will contain the most remarkable samples of the workshops of St. Etienne, and of the other centres of production, manufactured during the 18th and 19th centuries. Connected with these samples will be a collection of silks and other textile fabrics of European, Chinese, Japanese, and other Oriental countries; embroideries of all styles and periods; pictures of flowers, both native and exotic; sets of various *motifs* of decoration and ornamentation, &c. This collection is intended to serve to manufacturers and their designers as elements of technological study of inspiration in originating new designs. All these articles will, on demand, be sent to the houses of members of the society. In the commercial division will be found samples of all the productions of the day of foreign manufacturers, with indications of the prices for which they are exported, &c.; and these samples may be likewise borrowed by the members. The museum is also to constitute a kind of exhibition of weaving, in forming a collection of all the original "types," old and new, of the looms and other machinery employed in the entire world by manufacturers of ribbons and trimmings. As regards the second section, that devoted to arms, it is said that the Museum of Artillery at St. Etienne offers already a considerable collection of models, which, through galvanoplastic and other reproductions of the originals of the museums of artillery at Paris, Cluny, Moscow, Madrid, Turin, &c., may be rendered easily and at little expense very complete. Joined to these models will be photographic reproductions of pictures representing hunting and shooting scenes, of pictures of animals, and of everything useful to the designers and engravers of arms for field sport. The commercial division of this section is to be organised on the same principle as that of the first section. Specimens of new foreign arms will be carefully looked for and collected as soon as they make their appearance in the market. The third section is devoted to iron industries. Consul Malmros says that a prejudice, which fortunately is now dying out, has hitherto classed articles of ironmongery and of locksmiths' work as not belonging to the artistic industries. This, he states, is an error not shared by the French and Germans. The latter have established art schools for articles of ironmongery at Remscheid and at Iserlohn, and they have given a considerable place to works of the locksmith in their art museums at Berlin, Nuremburg, Munich, Dresden, and Hamburg. This section is to be organised on the same principle as the first two sections, and will contain typical models and specimens of all foreign, especially German, manufacture. There will be three classes

of subscription to the society—First, by members called founders (*membres fondateurs*), fixed at a minimum subscription of 100 francs; second, ordinary members, minimum subscription 25 francs; and third, associate members, minimum subscription five francs a year. In conclusion, Consul Malmros says, "The plan of this *Sociétié d'Art* is excellently conceived, and well worthy of imitation by other localities, in which industries admitting the application to them of art are carried on. It is significant of the progress made in such industries by other nations, and of the danger threatening from their competition, that even in St. Etienne such an institution as this library-museum should have become a necessity. For here, three hundred years of work and experience have developed a race of artisans in whom superior manual dexterity and delicacy of taste seem to have become innate, and one can hardly avoid the conclusion that no centre of industrial art can dispense with a museum, if in St. Etienne it is found indispensable for the further improvement of its workmen. That a museum of art applied to industry is the best means to complete the education the workman has received during his apprenticeship and in technical schools, there can be no longer any doubt."

MANUFACTURE OF BRUSHES IN THE BLACK FOREST.

The United States Consul at Mannheim in his last report says that to clock making, and straw weaving and plaiting, in the Black Forest, must now be added the manufacture of brushes. One hundred and fifty years ago people turned from mining lead and silver to other and more remunerative forms of employment. Spinning of cotton and brush making were introduced, the latter almost by accident. The introducer was a certain Leodegar Thoma, who assisted his father in a grist mill. He invented an instrument for bringing together the ground meal, which consisted of a rude brush made of rough wood, with rough holes and pig's bristles fastened together with nails. This was only a beginning, but the instrument, rough as it was, soon found customers in the neighbouring mills. The inventor then turned his time and attention exclusively to brush making, and succeeded in devising new and better methods of construction. From making brushes for flour mills he turned to making shoe, clothes, and horse brushes, and from his shop in the little Black Forest village of Todtnau, brushes found their way into Switzerland, Belgium, and France. About 1840, through one Franz Joseph Faller, the brush industry received a fresh impulse. Up to this time only common brushes had been manufactured, but the finest classes then began to be finished, and persons once more commenced to grow comparatively wealthy. The work was parcelled out among the people, Faller being satisfied with fair profits. The Grand Ducal Government assisted the young industry by granting premiums for the best results, and the directors and teachers of the industrial schools spared no effort to make success complete and gratifying. A scarcity of bristles soon compelled manufacturers to seek a substitute in the vegetable kingdom, and this was found in the fibre of a hemp-like plant found in Mexico; this discovery led to the production of a good, cheap article. Some time afterwards goat and horse hair were employed, also rice fibres, the latter especially for horse and scrubbing brushes. The bristles now used come chiefly from Russia, China, and North America. Machines were finally introduced, and they can now saw, turn, plane, and bore the woods. Machines have even been invented for putting in the bristles, but with no great success, and in the case of bent or oblique-surfaced brushes they cannot be used at all. The production is thus divided—first, sawing, boring, cutting, and turning the woods, then preparing the bristles, putting them in and fastening them; and, finally, veneering, painting, and polishing the brushes. In Todtnau there are twenty large brush factories in operation, employing over 600 hands. In addition, each family carries on the hand work at home, and children of eight and ten years of age are able to assist. The annual production is 2,000,000 brushes, valued at 800,000 marks, or £40,000. The wages of men engaged in this industry vary from 2s. to 3s. a day; women receive from 1s. to 2s., and children from 6d. to 10d. The wood used is a beech found in the Black Forest, which sells for 60s. to 70s. the cord. Oak, maple, linden, and cherry are also used. For veneers, mahogany, citron, and rose woods are much used. These are paid for by the pound, and are usually very expensive. The principal supply is sold in Germany and Switzerland, but of late years thousands are finding their way into Holland, England, and America. Consul Monaghan adds that the brush industry of the Black Forest, thanks to intelligent direction and encouragement on the part of the Grand Ducal Government by premiums, and on the part of the directors and teachers at the industrial schools, is in a position to meet the world in competition, both as to quality, cheapness, beauty, and rapidity of production.

COFFEE CULTIVATION IN BRAZIL.

The cultivation of coffee in Brazil has of late become so rapidly extended that this country exports in an average year 5,500,000 bales of 60 kilogrammes each, that is to say, more than half the consumption of the whole world, which is estimated at about 8,500,000 bales. The four provinces of Rio de Janeiro, San Paulo, Minas, and Espirito Santo, which together have a productive area of 960,000 square kilometres under coffee, form the centre zone of this culture in Brazil. Another, although much

less important, zone is formed by the provinces of Bahia and Geara. The other northern provinces do not export coffee, but this article is nevertheless grown there. In 1887 the production of the province of Pernambuco was almost sufficient to supply the local requirements. The area under *cafezals*, or coffee plantations, is continually on the increase, particularly in the provinces of San Paulo and Minas Geraes, which have large extents of uncultivated land. To make a coffee plantation the Brazilian agriculturist first chooses a plot of virgin forest where the soil is of excellent quality. The ground is then given up to *caboclos*, or native labourers, who cut down the trees, leaving only the largest ones. Fire is then applied, and the ground cleared. In the ground thus prepared maize is generally sown, and after the crop is gathered the preparation of the *cafezal* is commenced. Two systems are employed in this operation—(1) planting the seed directly in the ground, and (2) transplanting from slips which are grown at short intervals in a moist and shady spot selected for the purpose. The latter method is preferred. During the earlier years of the *cafezal* it is used for the cultivation of maize and beans, which are grown alternately, and occasionally between the young coffee plants sugar-cane is grown. These crops serve to protect the plants from the sun and the frosts, which are not infrequent in certain districts of the provinces of San Paulo and Minas Geraes. The plant begins to bear usually at the fourth year, if the system of transplanting has been adopted, and at the fifth or sixth if it has been grown from the seed. The tree is regarded as reaching its prime when ten years old. After twenty years, generally speaking, it becomes practically sterile, although if treated with proper care it may continue to produce fruit for forty years. The first flowering occurs usually in September (occasionally in August), and the last sometimes as late as January. The berry begins to form in November, and to ripen in April or May, at which time harvesting commences. Consul McCall, of Santos, says that in harvesting coffee in the province of San Paulo, the berries are stripped by hand from the branches, and dropped into baskets or on sheets. Very little care is exercised in this work, and green berries, leaves, and twigs are stripped off along with the ripe fruit. This lack of care results in the more or less unclean condition of the coffee after it is prepared for market, notwithstanding the various preliminary cleaning processes to which the berries are subjected. One of these processes is to wash the newly gathered berry in shallow cisterns filled with water. Thus washed, it is placed to dry on selected ground called the *terreiro*, which is completely open to the sun, and has a floor composed of some hard material—clay, stone, or cement. Here it remains about three weeks, pains being taken to protect it from the rain, for which purpose more or less frequent removals to shelter are necessary. In the process of drying, the skin of the berry turns black and forms a brittle hull, and the white sweet pulp disappears almost entirely, leaving on the kernel a very thin covering called the *pellicula*, or "silver skin." From the *terreiro* the berry is conveyed to bins, or *tulhas*, where it remains until it is to be passed through the machines which prepare it for market. The berry goes first to the *ventilador*, or windmill, where the dirt, stones, and sticks are blown away as much as possible; then to the *descascador*, where it is hulled. The bean thus liberated is passed to the *brunidor*, in which it is freed from the *pellicula* and polished; thence to the *separador*, where it is separated more or less completely, according to size and according to grade. It is now ready for placing in the sacks. What is called "washed coffee" is prepared by a different process. The berry is placed, just as it is gathered from the tree, in a tank of water, whence it passes with the water into the *despolpador*, which partially removes the pulp above mentioned. It is then conveyed, still mixed with water, into the *batidor*, or pounder, where, by means of revolving iron arms, the work of pulp removal is completed more or less perfectly. Thus treated, the bean has a very light bluish tint, almost white. After a few days of drying, it is ready for placing in the sacks. Washed coffee forms but a small per-centage of the entire production. It is, by reason of its lustrous, almost silvery appearance, a fancy article, although, says Consul McCall, quite inferior in flavour to coffee dried before preparation, owing, it is believed, to the fact that the bean is not allowed to absorb the pulp. It finds its chief consumption in France.

TOBACCO CULTIVATION IN COLOMBIA.

Mr. Wheeler, British Vice-Consul at Bogotá, in a recent report upon the agriculture of Colombia, says that there are four districts in Colombia, each very limited in extent, where tobacco is grown on a large scale; the Magdalena Valley, south of Honda, including Ambalema, Peñaliza, and Espinal, which three places supply most of the tobacco used in Bogotá and in the interior of the country; Palmyra, in the valley of the Cauca; Giron in the Department of Santander, and Carmen in the Department of Bolivar. The latter district produces more than all the rest together; but the greater part of its produce, which is of an inferior quality, is exported wholly to Bremen and Hamburg. Tobacco is, however, grown universally on a small scale all over the country, wherever, in fact, the climate does not render it practically impossible. Most of the farmers and cottagers in the warmer climates have a small plot of it, and dry and cure the leaves themselves, and make their own cigars. This, however, does not apply to the chief tobacco districts, where it does not pay so well to grow it on a small scale, and where, in case it is so grown, it is more advantageous to sell the crop at once to a large manufacturer. Tobacco thrives best

in Colombia at a temperature of from 75° to 85°. No great care is taken as to the quality of the soil, although the general opinion seems to be that a sandy soil suits it best, and its cultivation is carried on in a desultory and unscientific manner, quantity being more thought of than quality. It is partly owing to this, and partly also to various diseases which have attacked the crops in late years, and which have not been studied or understood, but still more owing to the competition of new tobacco-producing countries, that the export trade of Colombia has dwindled so greatly, and that the export of the superior tobacco of Ambalema, which was formerly one of the chief sources of wealth of the country, has practically collapsed altogether. In the Magdalena valley, tobacco is planted twice a year; in September, as soon as the rainy season sets in, for the chief crop of the year (*cosecha del ano*); and in February for the second crop (*cosecha de mitaca*). It is not the custom, as in some other countries, to cut and dry the whole plant at once, but the leaves are picked off as they ripen, beginning some two months after planting, and continuing, in some cases, for nearly the whole year. Before the plant flowers, a portion of the top is cut off, and then new shoots spring up from the roots, of which all but one are destroyed. This one is left to form a new plant, and in very good land three successive shoots will grow and produce crops in the year. In this way a plant will give a larger quantity of tobacco in the year than in most tobacco-growing countries. The plants are almost always grown from seed raised on the same plantation, few experiments being made with seeds from other districts or other countries. No manure is used, and the same land is used over and over again for an indefinite number of years. In some districts where disease has entirely exterminated the tobacco plantations it has been found that for a few years plants grown from seed brought from another district are not attacked, but that ultimately they also are destroyed. The leaves, when picked, are hung up to dry in the shade, under cover, for some twenty days, then put out at night to get slightly damp with the dew, and then packed up in bundles of twelve pounds weight, and left to ferment. They are then made into cigars without any further or artificial process of curing. Pipe tobacco is not made in Colombia. Cigarettes, which are very extensively smoked, are imported from Havana, or are made in Colombia from imported tobacco.

General Notes.

TEA.—The following particulars of the movements of tea (in lbs.), from 1st June to 31st July of the years are 1887–89, are taken from Messrs. Gow, Wilson, and Stanton's last report:—

	1887.	1888.	1889.
Imports.			
Indian ..	3,043,086	4,723,572	4,264,236
Ceylon ..	2,880,510	4,179,336	6,532,696
Java	621,390	604,870	545,650
China, &c.	23,122,006	29,435,885	12,787,518
Total lbs.	29,666,992	38,943,663	24,130,100
Deliveries.			
Indian ..	11,260,116	11,284,464	14,634,555
Ceylon ..	1,779,160	3,860,314	6,345,618
Java	653,450	634,970	769,720
China, &c.	19,062,671	19,355,301	13,220,016
Total lbs.	32,755,397	35,135,049	34,969,909
Stock.			
Indian ..	15,142,968	17,551,971	17,384,616
Ceylon ..	3,338,510	4,937,528	7,381,266
Java	1,022,350	884,380	1,009,750
China, &c.	47,005,316	54,472,530	36,912,766
Total lbs.	66,559,144	77,846,409	62,688,398

CARRIAGE MAKING.—Mr. John Philipson read a paper on "Modern Methods of Making and Selling Carriages," before the Institute of British Carriage Manufacturers, at Newcastle-on-Tyne, on the 5th inst., in which he drew attention to the rules laid down by the Duke of Beaufort and Lady Georgiana Curzon, as necessary in the building of a good carriage. Mr. Philipson remarks on the fact that the provincial manufacturer is now able to equal the standard of the London maker, and he adds that nearly all the patents for improvements in carriage building during the last twenty-five years are from the provinces. With respect to foreign makers, he says:—"After a careful comparison of French, German, Italian, and American carriages with English vehicles, my verdict is in favour of the English carriage as a whole. The French and Austrian show excellent taste in small details, and the German have many fancy fittings, but American methods are changing, and instead of the light spider wheels, a more substantial style is in demand by the wealthy. The outline and fittings are as nearly a copy of the English as is possible. The French carriages shown at the present International Exhibition bear out the arguments as to the advantage to be gained by making a superior carriage. For good workmanship, in decorating and finish at any rate, they could not well be surpassed, but the prices are in proportion, and in many cases far exceed the maximums I have named. The French coachmaker does not, at present, reduce the weight of his product to the minimum consistent with safety, nor does he sacrifice one little detail to cheapness."

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Proceedings of the Society.

CANTOR LECTURES.

EGYPTIAN TAPESTRY.

By Alan S. Cole.

Lecture I.—Delivered January 21, 1889.

The discovery near Akhmîm, in Upper Egypt, of burial grounds, from which a number of ornamental textiles have been taken, was, I believe, made within the last seven or eight years by Monsieur Maspero, the well-known archæologist and Oriental scholar, who has but recently resigned his direction of the Museum at Boulak. The first results of this discovery were lodged in that museum. Later ones have found their way to the Louvre, to Vienna, and to museums in England, Scotland, Ireland, and Germany. But, as far as I know, no more complete and representative collection of such Akhmîm textiles is to be seen than that at the South Kensington Museum. It is from this collection, therefore, that the photographs of specimens have been made which I shall have the pleasure of bringing before you in the course of the two Cantor lectures with the delivery of which the Society of Arts has entrusted me. Shedding new light upon the employment of certain most ancient processes of weaving, which in modified forms are in use at the present day, this South Kensington collection of Egyptian textiles also illustrates survivals and modifications of very old ornamental motives and designs. The why and the wherefore of these survivals and modifications are involved in conditions of people about whom very precise historic records are few and scattered. At the same time the range of events to explain these conditions is so extensive that, within the present limits, I cannot pretend to examine it adequately, or fairly to display it to you. I must, therefore, ask you to kindly regard my remarks as bare suggestions, and if fortunately they give rise to much more definite knowledge, I shall feel that I have not played falsely with you or my subject.

The title, "Egyptian Tapestry," under which my lectures have been announced, allows a wide scope. Some, no doubt, may have concluded that I would deal with the decorative wall hangings usually called tapestries, and solely with such of them as were made by the Egyptians. This, however, is not what I intend doing. For so far as the Egyptians are concerned, I propose to start from a date long after the exodus of the Israelites from Egypt, at which time the government of Egypt had passed through nearly eighteen dynasties, covering a period of probably 3,500 years. Whilst as regards tapestries, I have to deal with those found near Akhmîm, almost all of which are parts of costumes and cloths, few, if any, being wall hangings. The earliest of them, I think, does not date before Græco-Roman times in Egypt, or some time about the first and second centuries B.C. It may be right, however, to bear in mind that the peoples who made these things—some, possibly, 2,000 years ago—lived in a land in which, notwithstanding foreign invasions and internal strifes, there had been for thousands of years previously a continuity in beliefs, customs, handicrafts, &c. The system of government of Egypt appears to have varied but little under the different dynasties. The native as distinct from the foreign, dynasties indicate the supremacy at particular times of one or other of rulers of the the Egyptian provinces; and native dynasties seem to have assisted one another in perpetuating national traditions and usages. The provinces of Egypt, whence the native dynasties arose, corresponded with our counties; and Thinite, Memphite, Tanite Saite, and kindred dynasties would have found a parallel with regnal families of this country had there been a constant succession of Kentish, Northumbrian, Cornish, and such like English dynasties.

The condition of the town of Akhmîm at the present day, with its 18,000 inhabitants, its bazaar, market place, and walls, may not, perhaps, be very different from what it was

when known as "Ap, the abode of Khem," or later as Panopolis in the times of the Greek and Roman dominations. The burial places discovered by Monsieur Maspero are sandy wastes some three miles from the town. The textiles taken from them, I think, tell us that they belonged to inhabitants of Akhmîm and its district, who were subject to Greek, Græco-Roman, Syrian, Arabic, and Christian influences as these arose. The cemeteries were then preserved according to the traditional reverence for such places.

And here it may be convenient to display a rough map of Egypt and adjacent countries, noting their positions and those of certain towns. Migrations were made at various epochs to Egypt by the desert east of the Delta, from Assyria and Palestine, and from Persia. Arabs passed across the Red Sea. Greeks and Romans came over the Mediterranean. The positions of Babylon, Shushan, Persepolis, Ecbatana, Palmyra, and Alexandria are roughly indicated, as I shall have occasion to mention these centres.

Akhmîm was one of the many important towns along the Nile—that great highway of communication between Northern and Southern or Lower and Upper Egypt. It is on the left bank of the river as you go upstream, and is about halfway between Assiout on the north and Thebes on the south. Syene, further south, was the boundary town of Upper Egypt, adjoining the land of the Ethiopians. Akhmîm, or Panopolis, as it was called in the Grecian times, was, Herodotus tells us, noted for the productions of its weavers. In Egyptian houses generally, weavers were employed as commonly as cooks are with us. Distinction, therefore, in the art of weaving, which called for a special mention by the historian, must have implied a high degree of skill which survived for a long time, as the quality and ingenuity of the Akhmîm weavings prove. To this day Akhmîm has a reputation for weaving check cotton cloths. These, however, are quite different from what we are going to examine.

A picture of the typical Egyptian weaver is presented in a writing of the 12th dynasty, about 3,000 years B.C., and might almost apply now. Monsieur Maspero's translation of it is as follows:—"The weaver in the inner rooms of the house is more unfortunate than a woman. His knees are cramped up to his breast. He never tastes the free air. If for a single day he fails to make the full quantity of material required by regulation, he is bound together like the lotus of the swamps. Only by gifts of bread to the door porter can he steal a glimpse of open daylight." When I come to speak of the peculiarities of the textiles themselves I shall again have to refer to the weavers.

I will now very lightly touch upon the relations between Egyptians and other peoples, like Greeks, Syrians, and Romans, commencing a hundred years previously to Herodotus's visit to Egypt. This would place us in the reign of Ahmes, or Amasis, the last king of the 26th or Saite dynasty, which was followed in 527 B.C. by the Persian dynasty, established by Cambyses. It was Ahmes who granted great privileges to Greeks coming to settle in and trade with Egypt. His liberal concessions to the Greeks enabled them to found and develop the town of Naukratis, close to the Delta, which for many subsequent centuries was noted for Greek culture and manners. He also authorised Greek merchants to establish themselves elsewhere; thus temples to Greek gods and houses of business were set up in several Egyptian towns. At one, the Æginetans built a temple to Zeus; at another, the Milesians one to Apollo; at a third, the Samians erected one to Hera. Nine towns of Asia Minor co-operated in raising the Hellenion. "Upper Egypt," says Maspero, "and even the desert was not exempt from this kind of pacific invasion. Greek merchants speedily perceived the importance of having agents along the routes of the caravans coming from the interior of Africa. Milesians fixed themselves at the ancient city of Abydos, and certain of the Samians pushed as far as the great oasis." The natives of Panopolis or Akhmîm, according to Herodotus, showed no abhorrence of Greek customs, and actually adopted many of them. And yet in other parts of the Thebaid the presence of strangers like the Greeks surprised the natives, fomenting the hatred they entertained towards King Ahmes, whom they regarded as a usurper. The Greeks on their side brought back to their fellow countrymen wonderful tales concerning the distant regions they had penetrated, and excited cupidity at home by the sight of the riches, &c., they displayed on their return. Amongst these riches, no doubt, were Egyptian weavings; and at that early period we may perhaps, without a stretch of imagination, picture some Greek agents inducing Egyptian weavers to produce patterns more in accord with Greek taste than those which appealed to the sentiments of the

Egyptians only. Ahmes, or Amasis, sent one or two notable gifts of woven corslets to the Greeks. One, described by Herodotus, had "a vast number of animals inwoven into its fabric." In my lecture of the 12th April, 1886, I alluded to these corslets, and showed that they were probably woven after the manner of the tapestry-weaving process. Older still, by 700 years, is a corslet painted on the tomb of Rameses III. at Thebes. This, too, was no doubt of the same process of manufacture.

That the Greeks were acquainted with this particular method of inweaving coloured figures and ornament into materials is proved by specimens which were found in the Tomb of the Seven Brothers at Temriouck, formerly a Greek settlement in the province of Kouban, on the north-eastern shores of the Black Sea. Here is a fragment of one of the Kouban specimens. The tomb and its other contents, gold-work, &c., have been identified with the 3rd or 4th centuries, B.C. In the fragment before us, we have a powdered pattern of ducks, woven in coloured threads into the material surrounding them, and thus forming part of the whole fabric. The second specimen is of two bands or small strips of ornament, woven in the same way. These extraordinarily interesting specimens are most valuable links in the history of this particular process of weaving. As they were made within a hundred years or so of the period when Herodotus described the Egyptian corslets, it seemed more appropriate to refer to them now, than to reserve them for a later stage in the lecture when we have to deal with identically similar fabrics, but of different patterns, from Akhmîm.

As I said, the Saite dynasty, of which Ahmes was the last sovereign, was succeeded by a Persian dynasty under Cambyses. The Persian dynasty lasted for a hundred years, during which the Greeks remained allies of the Egyptians, aiding them to a large extent to recover their independence; this they maintained, however, for two brief native dynasties only, when the Persians, in 340 B.C., again conquered Egypt, holding dominion over her for seven or eight years. At this time Alexander had been prosecuting his wars in Persia, and finally vanquishing his opponent, Darius III., at Issus, in Syria, he marched southwards, on to Egypt, and proceeded to Memphis, which was then the centre of Egyptian Government. Alexander set to work to found the Ptolemaic or Greek domination of Egypt. From Memphis he passed down the river by the main western branch of the Nile, and having reached the Mediterranean he coasted in a south-westerly direction, and landed at the town of Rhacotis, which possessed natural advantages as a harbour. He decided to have a Greek town here, which shortly developed into the historic city of Alexandria, and superseded Memphis as the seat of Government. As principal port of Egypt it contributed vastly to the extension of Egyptian commerce with Greece, the Syrian coast, and Asia Minor, Italy, and especially Rome. Another event of some importance connected with Alexander's assumption of the government of Egypt, was his sending into Upper Egypt a body of seven thousand Samaritans, whose quarrels with the Jews made them glad to leave their own country. About a hundred years after this the Romans began to assert their influence in Egypt, which although nominally under the Ptolemies thenceforward became a Roman province. Monsieur Eugene Muntz, quoting from Athenæus, says, "Alexander's successors surpassed even him in a magnificence more Asiatic than Grecian in character. Alexandria became a noted centre for the revival of textile art. New scope was given to all branches of tapestry by the luxury displayed in the reign of Ptolemy Philadelphus. Splendid hangings depicting the portraits of kings or the stories of mythology, glistened in his dining-hall. Long-haired carpets, of fine purple-dyed wool, were spread before the couches alternately with short wrapped Persian rugs, ornamented with animal forms and other designs." The reign of the Ptolemies was brought to an end upon the defeat of Cleopatra by the Romans, at the battle of Actium, and Roman prefects were then appointed in Egypt. This course of conquest and changing Governments, which I have so hastily sketched, interfered with but did not completely paralyse the practice of the arts in Egypt, although "a vast number of sculptors, painters, and handicraftsmen of every description (including, of course, weavers), had been taken by Cambyses, about 525 B.C., from their country, and sent to Persia" to work. And this is an incident worth remembering in regard to certain weavings mentioned by Plutarch, which I shall refer to later on.

Trade continued its traffic up and down the Nile, and across the desert. Arabian and Indian goods destined for Alexandria, Greece, and Rome, came from Persia across Arabia, and were shipped westward over the Red Sea to ports like Berenice, not

far distant from Suakim. Thence they were carried by caravans across the desert to Coptos, which is about sixty miles south of Akhmîm. At Coptos the merchandise was placed on boats to proceed down the Nile, northwards. Greek and Roman wares destined for Egypt, Arabia, and India, travelled in an opposite direction over the same routes. Influences from such commerce would naturally communicate themselves at a place of the importance of Akhmîm, as well as elsewhere.

Notwithstanding that Egyptian types of ornament and architecture survived throughout the Ptolemaic and Roman dominations, and that Greek and Roman governors caused buildings to be erected in such styles, merely marking them with Greek inscriptions, it does not follow that an equally strict observance of Egyptian styles was respected in the minor arts. Greek and Roman patterns, as we shall see, were plentifully used in weaving—probably some years before Græco-Roman designs were employed for buildings and mosaics in Egypt, of which there are well-known examples assigned to the 1st and 2nd centuries A.D.

When, for instance, would such a specimen as the one now shown have been made? It comes from the Akhmîm burial grounds; it was the neck trimming of a robe. Its shape is more like that of most ancient Egyptian than that of Roman neck trimmings. The ornament, a repetition of anthemions or popularly termed honeysuckle devices, is, I venture to say, of pure Greek character. There is no trace of those florid forms in which the radiations of this favourite device were subsequently rendered. Of course, it is possible that it may be only an out-of-date survival. On the other hand, it is one of a great number of specimens which display varieties of ornament that appear to have succeeded one another throughout a long range of time.

In other things, Roman influence, as Dr. Birch has pointed out, is noticeable. Jars and vases for wine and milk were often shaped like Roman *ollæ*. Again, the god Isis, adopted in Egypt from Arabia, has been represented in the dress of a Roman soldier. Conversely, the Romans cultivated a taste for Egyptian decorations, &c., when Augustus, on his return from Alexandria, publicly displayed, in Rome, Egyptian treasures, ornaments, and trophies; when obelisks began to be set up in Rome; when the worship of Isis and its foreign ritual became fashionable there; when Egyptian crocodiles walked and swam in the theatre; and, later still, when consuls like Junius Bassius decorated their houses with mosaics in which groups of Roman gods and warriors are separated from one another by bands of Egyptian gods—such designs were clearly depicted by a Roman hand.

To return, however, to my outline of the history of Egypt. Augustus relieved the country from the presence and controlling authority of powerful Romans. Levying taxes was a good deal left to the care of natives, especially in Upper Egypt and the Thebaid, the receipt of the taxes being there entrusted to Roman prefects. From A.D. 96 to 260 the force of the spirit of Græco-Roman art generally was broken by the inroad of foreign ideas, especially those derived from Syria and Asia Minor. These countries were at that time the most flourishing provinces within the area of the Roman Empire, according to Müller, and an Asiatic character emanating from thence is very noticeable in the arts of design as well as of literature. A mixture of Greek with indigenous forms, in what Greeks and Romans termed, countries of the barbarians, among which Upper Egypt may be included, appears to belong chiefly to the period when Marcus Aurelius was Emperor. On the death of Claudius, about A.D. 270, the Palmyrenes renewed their attacks upon Egypt, and this second time with success. The whole kingdom (says Sharpe in his "History of Egypt") acknowledged Zenobia (Queen of Palmyra) as their queen. The Greeks, who had been masters of Egypt for six hundred years, ever since the time of Alexander the Great, either in their own name or in that of the Roman Emperors, were then for the first time governed by an Asiatic. Palmyra was ornamented with spoils from Egypt. The red porphyry columns at Palmyra are considered to have been quarried from between Thebes and the Red Sea, and shaped by Egyptian artisans, under the guidance of Greek artists in the service of the Romans. Zenobia's soldiery consisted largely of Arabs, whose presence in Upper Egypt gave new courage to that portion of the population which, known as Blemmyes, belonged to the same sort of Arabic nationality. With such forces at work, although Zenobia had been vanquished by the Romans, the assertion of Arabic or Syrian influence in the neighbourhood of Coptos and in Upper Egypt gained strength. Diocletian then attempted to check this. But although he destroyed many towns, the native Egyptians, the Copts, and Arabs, rose into notice, and Græco-Roman civilisation

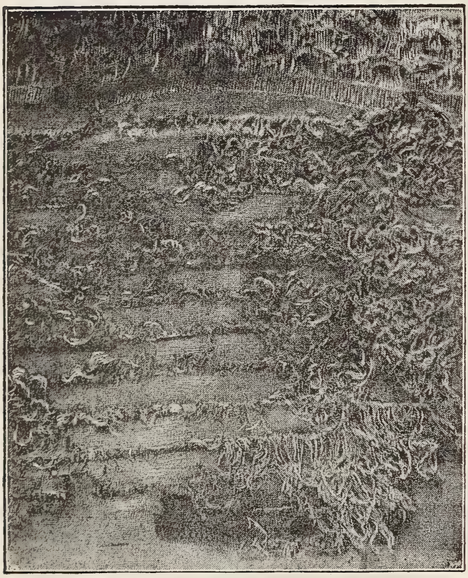
dwindled. At the time of Constantine (323-337) the falling state of the Roman Empire rendered the towns and villages in Egypt more or less dependent upon themselves for their defence and government. Orders from Constantinople were little heeded in Upper Egypt. The people chiefly looked to their own ecclesiastical authorities for direction. Christian monks in the Thebaid became the models of discipline, which the Alexandrians imitated. The monasteries there were probably prototypes of those kindred institutions which began to flourish in Europe about this time. Besides attending to their religious offices the monks worked laboriously with their hands, employing themselves amongst other occupations with weaving and the arts of design, especially of patterns for ornaments and MSS. Earnest Christians from Italy travelled to the Thebaid to acquaint themselves more thoroughly with the organisation of the Coptic monasteries. Doubtless they would return home taking with them weavings of all sorts, and in this connection the painting in Christian catacombs of Rome furnish us with interesting evidence of the employment by Christians, in the third to the fifth centuries, of decorated robes similar to those which have been found at Akhmîm. As to these we shall see more later on. Towards 450 A.D. many zealots from Italy flocked to the Theban monasteries to place themselves under the severe discipline of the Coptic monks. And this inroad of Roman influence naturally affected those arts which were practised to the glory of Christianity in Egypt. Sharpe, in his history, gives a wood-cut of a painting of St. Peter, which was done upon part of an ancient carving of Rameses II. with Egyptian gods. The effigy of St. Peter was made to take the place of those of one of these latter, with the result that the Egyptian king appears as presenting an offering to the Christian saint. A considerable quantity of Christian architecture, &c., was erected during the 160 years between the defeat of the Nubians by Diocletian, A.D. 290, and their victories in the reign of Marcian, A.D. 450. A few rare bits of stone, sculptured with apostles under pointed niches, have been recently acquired for the South Kensington Museum. They came from Akhmîm, and are presumably the work of Christian Copts. They appear, however, to belong to a rather later period than the 5th century. They are rude in form and execution, and in this respect correspond with some of the Akhmîm weavings, made about the 8th century. In the early part of the 6th century the Persians began to encroach upon Egypt. Syrians also came in numbers somewhat later to study the religious life in the Christian monasteries. For ten years of the 7th century Egypt was once more governed by the Persians. About 623 the Arabs swept down upon the Persians in Egypt, and twenty years later the country ceased to be a Græco-Roman province. Further than this point I do not propose to go. I imagine that the Akhmîm textiles were produced at periods between the 1st century, B.C., and the 7th or 8th century, A.D., and having said this much, I turn to the different sorts of weaving which these textiles exhibit.

Traditional flax weaving was produced by throwing threads right across and in between two ranks of warp threads, and pressing them down with a batten or flat strip of wood, rather more than the width of the warp rank. The Beni-Hassan paintings of the weavers at work furnish a representation of the use of this process 2,000 years B.C. The weaving frames were such as are now called low warp looms, which either are laid upon, or are parallel with, the ground; not vertical or at right angles with it. In most Egyptian flax weaving it is found that warp are finer than the weft threads; these latter being the stouter, were therefore more conveniently passed between the ranks of finer warp threads. This feature is noticeable in the linen portions of the Akhmîm textiles. Beyond this, some linens are of very close texture, and others are open, like square-meshed canvas. The flax in certain of them is so glossy and soft as to lead one at first sight to mistake it for silk. Microscopical examination of the fibres, however, corrects this. Such of the Akhmîm specimens as are of silk form a class altogether distinct in character from the linen and woollen ones. The plain flax weaving was not employed for ornamental purposes; for these, other methods of weaving were adopted. But before referring to these, I may mention certain woven materials which are not ornamental, and differ in fabric from the plain linen weavings.

It was no doubt as much for warmth as well as for variety in texture, that a certain class of linen textiles was produced with a shaggy surface corresponding with that of modern bath towels. Here, for instance, is a specimen of such material; the ancient production and employment of which have been treated at considerable length by Monsieur Heuzey in a recent number of the *Revue Archeologique*.

His researches are of such interest, and have so close a bearing upon the shaggy-surfaced textiles taken from Akhmîm, that I have ventured to make a brief *resumé* of them. They develope suggestions as to a Greek textile called *kaunakes*, which occur in the Onomasticon by Pollux. Of this author, having similar inclinations as Pliny, but writing a hundred years later, it is interesting to note that he was a native of the old Greek town of Naukratis in Egypt, and that his references therefore to textiles seem to throw light upon those from Akhmîm.

Fig. 1.



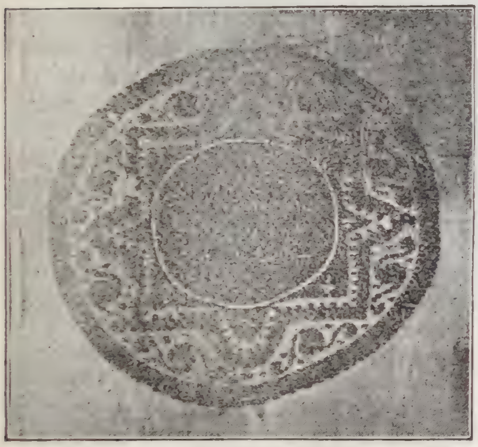
Tufted or shaggy-faced woven linen (from Akhmîm) similar to the *kaunakes*, or *phlocata*, of the Greeks, and *gausapum* of the Romans.

Monsieur Heuzey produces good reasons for believing that shaggy-faced textiles similar to the one before us were manufactured 2,000 years B.C. Many of the little Chaldæan cylinders are engraved with figures, some of whom wear crinkled or pleated-looking garments. The same character is seen in sculptures from Nimroud. The conventional renderings of hairy surfaces, such as manes of lions, have led Monsieur Heuzey to the conclusion that these apparent crinkles and pleats are conventional renderings of shaggy surfaced stuffs—representations in fact of series of loops or fringes. Now Pollux, in writing of the *kaunakes* material, refers to dialogues upon this textile, which pass between Philocleon and Bdelycleon, two characters in the "Wasps" of Aristophanes. Bdelycleon is pressing his friend to wear a shaggy mantle. "Some," he says, "Call it a Persian cloak, others a *kaunakes*." Philocleon fancies it to be a Thymetan wrapper—the ancient village of Thymetes in Greece being noted at that time for the manufacture of shaggy or rough material known there as *sisyra*. "No wonder," retorts Bdelycleon, who displays a great deal of knowledge about these fabrics, "for you cannot have been to Sardis, or you would have known better." Mantles, like the one he is offering are, he explains, made at Ecbatana—hence the reason for calling them Persian. "What," says his companion, referring to the rows of loops on the mantle, "is woollen tripe made at Ecbatana?" Upon which Bdelycleon, taking him literally, rejoins, "By no means, my good sir; this is woven by the barbarians at a great expense; of a surety this very mantle must have required a talent of wool in its making." "Pray, then," asks Philocleon, "ought we not more properly to call it wool consumer than *kaunakes*?" From which Monsieur Heuzey concludes that the make of *kaunakes* was similar to that of the wool consumer made by the barbarians at Ecbatana. A figure of Perso-Assyrian sculpture at Parsagadœ, dating before Alexander's conquests in the district, wears a shaggy-faced robe, and this whilst possibly representing the "wool consuming" fabric is distinctly of the same character as the shaggy weaving from Akhmîm. The *phlocata* of the Greeks, in use in some parts of Greece at the present day, also would correspond with the "wool consumer," as well as in a degree with the *kaunakes*. Hesychius writes of one class of *kaunakes* as being *etero-malla*, or shaggy on one side only. Pliny, moreover, writes, "I, myself, recollect the *amphi-malla* (a material shaggy on both sides), and the long shaggy apron being introduced, but at the present day the *lati-clave* tunic is beginning to be manufactured in imitation of the *gausapa*." The *gausapum* was usually a woollen textile, something like felt or flannel. But it was also made of linen, and then with a shaggy surface. Now, here is a fragment of a *lati-clave* tunic from Akhmîm, made of linen. It is probably of the material which the Greeks would have called *kaunakes*, and the Romans *amphi-malla*, and perhaps *gausapa*. Monsieur Heuzey showed a specimen of the

shaggy linen material from Akhmîm to the director of the Gobelins Tapestry Works, and he at once identified its manufacture as one in which modern tapestry weavers would employ what is traditionally known to them as the Saracenic knot. The peculiarity of covering the face of a textile with series of loops enters into the manufacture of velvet. In that case the loops are very small and ranged closely together; they are cut through, and so form the pile. A further modification of what seems to be the classic *kaunakes* is to be noted in other specimens from Akhmîm, in which the ranks of loops are wide apart, with intervening linen between them, as in this specimen.

I now pass to another sort of textile from Akhmîm. The work on this linen appears to have been done with a needle. The loops here are made of worsteds; they are much

FIG. 2.



Looped Worsted Embroidery on Stout Linen; from Akhmîm.

shorter, and compacted more closely together, than the linen loops of the *kaunakes*. The texture of this roundel, inclosing a star device worked with close short loops of worsted, has some resemblance to that of a Turkey carpet. The method of making a carpet, however, is quite different from this embroidery.

It appears from fragments found together at Akhmîm, that small lengths of reed were used to regulate the size of the loops. Here are photographs of the fragments in question. The linen to be embroidered with short loops of worsted was probably first stretched out in a frame. A reed was then fastened by a stitch or two to the face of the linen at the place where the loops were to be worked. The needle, charged with worsted or flax, was then pushed through from the under side of the linen close to one side of the reed; the worsted was then brought over the reed, and the needle pushed down through the face of the linen close to the spot where it had entered the linen from underneath. Thus a loop around the reed had been worked, and successive loops were similarly made. The reed was then withdrawn and so a rank of loops was left standing on the face of the linen. The small fragment below shows the reeds or little sticks still enveloped by loops of worsted.

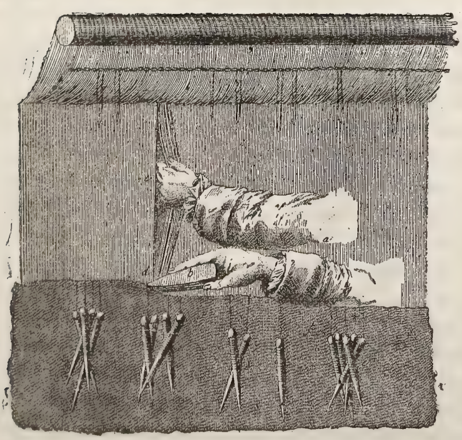
But embroidery of this description was made with finer worsted in smaller loops, and probably without the intervention of small reeds. A corner of a cloth worked in this way is at the British Museum, having been presented to the Museum by Mr. Greville Chester, who has visited Egypt and investigated the textiles and embroideries taken not only from Akhmîm, but also from other burial places further north, at which weaving and embroidery were produced of the same character as at Akhmîm. I am glad to be able to show you the British Museum embroidery in this photograph. The colours in the original are bright. The two little winged figures are wrought in flesh colour. The one on the left has blue and green wings, and wears a drapery of red. The drapery of that on the right is blue and green. They are rowing in a fancifully shaped boat, the upturned ends of which are according to Egyptian tradition. Below the prow on the right, part of a fish is visible; on the other side is a rosebud; elsewhere buds are to be seen. The border consists of green and coloured leafage, with a man's face in a roundel at the corner. The style of ornament and treatment is more Roman than Egyptian. We might imagine that some Græco-Roman designer, possibly of the time of Cleopatra, had drawn and coloured the pattern, and that it had been worked by an Egyptian embroiderer. The character of the design is such, however, as might also belong to a century or so later. Yates, in his *Textrinum Antiquorum*, quotes a passage from the life of the Emperor Carinus (3rd century, A D.), by Flavius Vopiscus, "Why should I mention the linen cloths brought from Egypt . . . . prized on account of their laboured embroidery." And it can be well understood that such an embroidered linen as the one before us would be prized by a Roman of that time.

The third and most numerously represented section of Akhmîm textiles is that in which, to quote Herodotus, patterns are inwrought into the linen. The process employed for such inwoven ornament is the same as that which was used by the great Flemish weavers, on a far larger scale, for making their splendid war tapestries, and is now commonly known as the tapestry-weaving or Gobelins process. It is quite distinct from weaving in a loom with a shuttle. It is minutely described by Ovid in his story of Minerva and Arachne. (Metamorphoses VI., 55, 69.)

FIG. 3.

Gobelins Tapestry Weaver, 18th century.

FIG. 4.



Use of Comb in Gobelins Tapestry Weaving, 18th century.

Arachne was the daughter of Idmon, a Lydian dyer, and was noted for her skill in all sorts of wool work—in spinning, weaving, and embroidering; but she denied being under any obligation to Minerva for her skill in these arts. So assured was she of her supreme ability, that she confidently exclaimed, "Let the goddess contend with me. There is nothing which, if conquered, I should refuse to endure." Accordingly Minerva, disguised as an old woman, comes to her and urges her to hearken to advice: "Let the greatest fame for working wool be sought by thee amongst mortals; but yield to the goddess, rash woman, and ask pardon for thy speeches." Spurning this advice, Arachne demands why

the goddess does not come herself? Why does she decline a contest? Then casting aside the figure of an old woman Minerva reveals herself, "Lo! she is come." Arachne, unabashed, repeats her challenge, which the daughter of Jupiter accepts. There is no delay; they both take their stand at different places, and stretch out two webs with fine warp. The web is tied around the beam, the batten separates the web, the wool is inserted with pointed bobbins hurried along by the fingers, and being drawn within the warp is struck down with the comb, through the teeth of which the warp threads pass. The separate designs grow rapidly under the skilful fingers. That wrought by Minerva represented her genius in producing a shoot of pale olive with berries, by touching the earth with her spear, and Neptune's magic art in causing a horse to spring from a rock which he strikes with his trident. At the four corners of this central group of figures she introduced combats of gods with mortals, and between these placed bands of olive branches. Arachne, on the other hand, depicted a series of episodes in the amours of the gods, or as Minerva stigmatised them, "the criminal acts of the gods of heaven," and surrounded them with a border of ivy leaf garlands interlaced with flowers. The competition is apparently terminated in an abrupt manner by Minerva, who, incensed at the subjects depicted by Arachne, rends the weaving in pieces, and strikes the hapless mortal on the head three or four times with her bobbins. This degradation is too much for Arachne, who forthwith proceeds to hang herself. She is suspended in mid-air from a tree, when Minerva changes her into a spider, "and as such Arachne works at her web as formerly." Poetical imagination takes no account of the time which ordinary mortals would have consumed before they could have made much appreciable progress with such elaborately patterned tapestries. The realism of the scene is enforced, however, by Ovid's precision in describing the weaving operations. It is certain that he must have been thoroughly conversant with them, either through personal observation of what was surely an everyday occupation at his time, or from information derived from some practised worker. We may test Ovid's accuracy by means of diagrams taken from a last century dictionary of manufactures. These diagrams show us the process of tapestry weaving at the Gobelins factory, which is the same to the present day.

In Fig. 3 (p. 794) we have a frame with its web of warp threads, and a man passing a bobbin thread in between and around them. Fig. 4 is another diagram of the worker using a comb to compress the weavings of the bobbin threads. These diagrams refer to work on a somewhat larger scale than that apparently adopted by Minerva and Arachne.

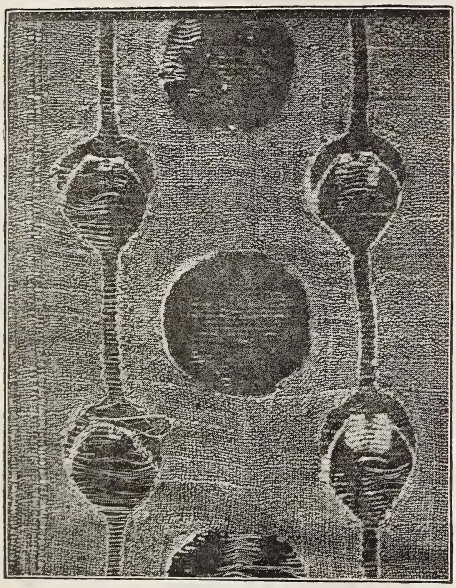
The Egyptians of Akhmîm, who made use of a precisely similar process, did so for a great deal of work wrought on a far smaller scale in comparatively small frames. Here we have a diagram of an old Egyptian frame, and workmen arranging it for weaving. Above it is a hieroglyphic, which includes amongst other signs a bobbin pointed at both ends, and indented and rounded at the centre to carry thread, and pass easily between and around the warp. Near the bobbin is a comb for compressing the weaving. The bobbin and the comb are the principal implements in this process.

As I have said, ornamental weavings from Akhmîm, by means of this bobbin and comb method, were inwrought chiefly with worsteds into linens. Where the ornament was to appear the linen weaver left spaces crossed by warp threads only—a feature in employing the process which was noticeable in the Greek weavings from Kouban already mentioned. I now display a diagram (Fig. 5, p. 796) of linen from Akhmîm inwoven in the same way with ornament. Parts of the worsted ornaments have been eaten away. The old law or custom of Egypt proscribed the use of wool in burial dresses, "in consequence of its engendering worms" (Wilkinson). Thus the presence of worsted in these Akhmîm textiles shows at least that they were made for persons who were not bound by traditional Egyptian custom, such, for instance, as Greeks, Romans, and Christian Copts. The partial disappearance of the wool testifies to the wisdom of the Egyptians in taking precautions against the engendering of worms in the tombs. At the same time, this disappearance of the wool has enabled us to clearly trace the flax warp threads across the open spaces of the linen. Upon these flax warps the wool was originally twisted. On the back of most of the worsted weavings we have the weft flax threads lying loose.

Other specimens of Akhmîm tapestry weavings may perhaps have been made separately and then sewn on to linen, as in this specimen.

Such *appliqué* work would be well suited to embellishing a somewhat worn linen robe. The Romans certainly had such a fashion, as Pliny remarks, "that a garment when it has been worn for some time is often embroidered with wool from Egypt." We have noted the important part which a comb, for compressing the weaving, plays in the process. This, as Ovid has proved, was thoroughly understood by Romans in the 1st century B.C., and Martial refers also to it in one of his epigrams, where he writes of a cloth, "The land of Memphis makes you this present. The Babylonian needle is now surpassed by the comb of the Nile."

FIG. 5.



Piece of linen with coloured worsted tapestry weavings.

Before leaving the subject of tapestry-weaving or comb work for the ornamentation of costumes and linen cloths, coverlets, &c., I should like incidentally to direct your notice to the remarkably interesting specimens of identical manufacture which, like those of Akhmîm, have been taken from graves or tombs sunk in the sandy soil of a more southerly latitude than Upper Egypt, but on the opposite side of the world—I allude to Peru. The Necropolis of Ancon—near the Pacific Coast and to the north of Lima—has been explored of recent years. It is the first of such Peruvian burial-places which has been investigated. Ancon was the settlement of a comparatively poor population.

The system of burial in vogue there during the Inca empire, and the soil and climate, have contributed to the preservation of a great number of ornamental textiles, woven in identically the same manner as the Akhmîm specimens. The patterns, however, are ruder, although some of the details even are similar.

Here is a specimen in which a Greek key pattern occurs. This pattern, however, is virtually universal, and is as much the property of the Greeks as it is of the Chinese. Here is the figure possibly of an Inca chieftain carrying the head of one of his victims. And here is a characteristic Peruvian ornament in which we can detect the Greek wave pattern, which, like the key pattern, belongs entirely to no one nation.

The circumstances under which the early Peruvians wove such textiles as those just seen, must extend over periods to tell the story of which would undoubtedly require a separate lecture; I do not, therefore, propose to touch upon them. But I may perhaps say that the various articles taken from the Peruvian graves at Ancon have been photographed, and a large work in sixteen folios containing coloured fac-similes of them, has been published by Messrs. Asher and Co., with the aid of the General Administration of the Royal Museums of Berlin.

Besides the textiles we have considered this evening, fragments of elaborately patterned silks have been brought from Akhmîm and elsewhere in Egypt. For the most part, these silks are of a Syrian and Byzantine character. Some are reproductions of patterns wrought in the worsted and flax tapestry weavings. It is possible that such silks date from about the 6th or 7th century, when the use of silk in Europe was becoming general. Within present limits I find that I shall not be able to treat more fully of these silks.

Briefly put, the points of this evening's lecture are as follows:—A variety of textiles is discovered at Akhmîm, in Upper Egypt. Between the 7th century B.C. to the 7th century A D., this place, like others in Egypt, has been subjected to foreign influences, such as Persian, Greek, Roman, Syrian, and Arabian or Saracenic. These influences have left their marks upon the productions of local artisans

skilled in processes of textile manufacture and embroidery, the art of which they inherited from their forefathers, the ancient Egyptians of Bible history. Other and later nations were also versed in many of these processes. We have seen shaggy-surfaced linens from Akhmîm which correspond with similar stuffs made by Assyrians, Persians, Greeks, and Romans. We have noted Akhmîm worsted embroideries which, according to Roman writers of the Augustan period, were apparently well known to the Romans of that age. We have found that a tapestry-weaving process, in which a hand-comb is an important implement, was used by old Egyptians, Greeks, and Akhmîm weavers, as well as by Peruvians; and from this fact, coupled with others of identical character in respect of the Indians, Chinese, and natives of Islands like Borneo, the deduction is fairly made that this tapestry-weaving process is amongst the earliest of ornamental textile processes. It is early in date when traced in connection with historic peoples, and early in usage with people of primitive culture. It was extensively used by weavers at Akhmîm, at the beginning of the Christian era, for the decoration of articles of costume and of hangings. The Romans employed it for textile pictures, as Ovid has told us. We know that for making similar things it has been for more than 300 years, and still is, in use at the Gobelins manufactory. We know, too, that we are indebted to it for the examples handed down to us of those gorgeous wall hangings which bedecked the halls and castles of European countries between the 14th and 17th centuries.

From the earliest to the latest times known to us there have been ebbs and flows in the tide of human skill in processes for making textiles. Whilst modifications have been introduced into them at different times, the principles of them have remained the same throughout.

My first lecture having dealt chiefly with the processes, my second will relate to ornamental designs as interpreted at Akhmîm by those processes. Next Monday, therefore, I propose to bring before you a number of examples made at Akhmîm. They exhibit a great variety of patterns and dress ornaments, and by comparing them with similar ornaments in things of which the dates of production are authenticated, I hope to establish approximate dates of the manufacture of the Akhmîm specimens.

Miscellaneous.

COMMERCIAL EDUCATION IN GERMANY.

A report by Vice-Consul Ferdinand Ladenburg, at Mannheim, on the early training of German clerks, has been printed by the Foreign-office, from which the following notes have been taken:—

Whatever merits the German clerk possesses, are unquestionably largely due to his having to serve for two, three, or even four years as an apprentice before he can become clerk. Excellent as the school system is, it is not adapted or intended for producing excellence in any one direction. Between the youth of England and Germany, in point of talent, energy, and industry there is little or no difference. The German youth is more provincial, perhaps steadier, more diligent, and bent on self-education. The English youth, by reason of the predominance of cities in England is, on the other hand, probably quicker, more intelligent, impulsive, and, for the moment at least, more energetic. On leaving school the German is rarely a good ready-reckoner, can often not write a good, plain hand, and very seldom expresses himself simply and clearly in writing. The systematic excellence of his schooling has, however, so far strengthened and developed his mental powers that, given time, his grasp of a subject may easily become far superior to that of his English compeer. This advantage, mainly neutralised by life in Germany being so much simpler, asserts itself in full force after the young German has been some time in England, when, if not crushed, he is lifted and invigorated by the greater intensity of English life. Then it must also not be forgotten that the English youth has only one experience, while the German has two, that of his own land, and that of the new country, and his vision is freshened and sharpened, and his energies strengthened accordingly. Apart from these conditions, however, the superiority of German clerks in general to the English is, I think, quite illusory. German bankers, merchants, and manufacturers are constantly complaining of the difficulty of obtaining efficient assistants. It is part of a general complaint. Although since 1870 the younger generation in Germany have become far more energetic and enterprising, and make far higher pretentions, yet they have become less steady, industrious, and reliable. Almost all the Mercantile Unions ("Kaufmännische Vereine") complain that they have to assist young men seeking places in ever-increasing numbers, who are either very inefficient, or even unworthy of a place. The German clerks who go to England and other countries are frequently the very best. As a rule they are the most energetic, boldest, and most enterprising. Besides, most of them are North Germans, who are generally more

energetic and practical than the South Germans. England probably has no reason to regret that a number of the most efficient workers from a foreign country seek her shores, the more so, since most of them remain and become her most faithful citizens. If every year a number of the best and most active English clerks sought situations in Germany, there would perhaps soon be a new and similar complaint.

The rise of German commerce, and its gradually becoming a formidable competitor of English trade, is attributed not so much to any superior knowledge and skill on the part of the German merchant—for, in point of experience of non-European markets, the English manufacturer and merchant are prabably far in advance—but to the greater boldness, energy, and enterprise of the German trader, the result of the great political change in Germany. Such competition may become more effective as German manufacturers gain experience, but that is a matter of time, and at present their trade with most countries outside Europe is in its infancy. That commerce, meanwhile, is likely to prosper most that secures to itself the best workers, and one cannot separate the clerk from the merchant. A solid foundation to slow, gradual, but certain improvement might most likely be gained by the system of apprenticeship, coupled by the apprentices attaining a thorough knowledge of at least one foreign language—European or Oriental—and the dispatch of English clerks to foreign countries to qualify themselves for travellers.

General Notes.

Silk Exhibition, 1890.—The Silk Association is arranging to hold in London, next spring, an Exhibition of the Silk Manufactures in the United Kingdom and Ireland. In order to place before the public the capabilities of the home industry for supplying its requirements, it has been decided that the exhibition should contain specimens of various branches, consisting, among others, of broad and narrow silk fabrics, including poplins, &c., also lace, embroidery, silk hosiery, costumes, fans, trimmings, sewing and embroidery silks, twists, cords, &c.; thrown silks, Indian and British Colonial raw silks, &c.; exhibits illustrative of the growth of silk, of the processes of manufacture, and of the printing, dyeing, and finishing of silk; various silk handicrafts in operation; industrial and decorative design as applied to silk fabrics.

Forest Administration of Bombay.—From the last report of the Forest Department of the Bombay Presidency it appears that the receipts and expenditure at the close of the year were respectively Rs. 30,35,577 and Rs. 19,35,522, showing a net profit of Rs. 11,00,055. Ever since the Indian Forest Act became law the Government has from year to year notified vast areas of waste land as "forest," and concurrently with these notifications has been carried on a careful and judicious system of forest settlement and demarcation by officers who have been specially appointed to inquire into and determine the existence, nature, and extent of all rights claimed by individuals within the notified areas. At the present moment the total forest area under the control of the Bombay Forest Department amounts to 9,837 square miles "reserved," and 4,479 square miles "protected." In Scinde the action of the Indus is always important. During the year under review the losses of forest lands washed away by the river have been serious, but on the other hand, over 7,000 acres ot alluvial accretions were thrown up on the frontages of forests by the river. Protection against fire has been attended with success, for there has been a decrease in the number of fires. One of the conservators proposes a close season for game within his charge. Of late years bison and deer have been rapidly disappearing in Kanara.

Textile Fibre of the Banana.—The *Handels Museum* states, on consular authority, that the fibres of the banana, or paradise fig plant, are the most important products of the soil there which have hitherto remained quite unused. This fibre, which is capable of being divided into threads of a silky fineness, extends the entire length of the plant, which has no branches. In Central America this fibre, without any other preparation than the drying, is used for shoestrings, and for strings and ropes for various purposes. During the twelve months of its vegetation the banana plant produces only a single bunch of fruit, after which it dies, but from its roots four to ten young plants spring up. In its native place a bunch of fruit of the banana is worth about one shilling, whilst the plant, which is thrown away, is worth ten times that amount to a soap factory, paper mill, or coffee bag manufacturer. The leaf of the banana, composed with its stalk of the toughest and finest threads, has hitherto only served the native women as an umbrella during the rainy season, as a carpet to sit upon, or a bed to sleep on. "If," says the *Handels Museum*, "this plant in the innumerable banana plantations of the entire tropical world is only properly utilised, the whole human race will obtain such a vast mass of textile material that it is certain to influence the value and cultivation of other kindred plants, such as hemp and flax, cotton, jute, &c., and nobody can predict the consequences which the utilisation of this hitherto unnoticed material may have."

American Ice Trade.—The capital invested in the ice trade of the United States is estimated at 18,000,000 dollars. The quantity of ice collected annually at the date of the last census amounted to 10,000,000 tons, and there are some localities in America where as much money is expended annually in ice as in fuel.

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FRIDAY, SEPTEMBER 13, 1889.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

ART-WORKMANSHIP PRIZES.

The Society of Arts offer the sum of £150 in money prizes, as well as twenty of the Society's Bronze Medals, for objects in the Arts and Crafts Exhibition to be held in the autumn of the present year. The judges will be empowered to distribute the money, or such proportion of it as they see fit, in any sums they think will best meet the relative merits of the exhibits, at the same time paying due regard to the cost of production. The whole sum will only be expended in case of works of sufficient merit being forthcoming.

It will be understood that the Arts and Crafts Exhibition Society do not undertake responsibility in respect of the awards of the prizes, which will be a matter solely under the control of the Society of Arts.

The rules under which the prizes will be offered are substantially the same as those under which the previous art-workmanship competitions of the Society have been carried out.

The Exhibition of the Arts and Crafts Exhibition Society will open at the New Gallery, Regent-street, on Monday, October 7th, and will close on December 7th.

The following is the classification of the objects to be received for exhibition, as put forth by the Arts and Crafts Society:—

(a) Designs and cartoons for decoration of all kinds.
(b) Decorative painting—more particularly in association with architecture or cabinet work.
(c) Textiles—Tapestry, Needlework, woven and printed patterned Fabrics, Lace.
(d) Painted glass.
(e) Pottery—Tiles, Majolica, painted China.
(f) Table glass.
(g) Metal work—Wrought iron, brass and copper Repoussé, Gold and Silversmith's work and Chasing.
(h) Wood-carving } Carving in ivory and
(i) Stone-carving } other materials.
(j) Cabinet work—inlaid, and painted and carved furniture.
(k) Decorative Sculpture and Modelled Work—Friezes, architectural enrichments, relievos, plaster and gesso work, &c.
(l) Printing—Book decoration, Printers' ornaments, Illuminations and decorative MSS. Wood and metal engraving.
(m) Book-binding and cloth-cases.
(n) Wall papers.
(o) Stencilling.
(p) Leather work—Stamped, tooled, cuir-bouilli, &c.

And such other kinds of decorative Art not above enumerated as may be approved by the Selection Committee.

Information respecting the Exhibition and forms of application may be obtained from Mr. Ernest Radford, Secretary of the Arts and Crafts Exhibition Society, at the office, 44, Great Marlborough-street, London, W.

The receiving days at the new gallery are Monday, Tuesday, and Wednesday, the 16th, 17th, and 18th September, after which date no work can be received.

Proceedings of the Society.

CANTOR LECTURES.

EGYPTIAN TAPESTRY.

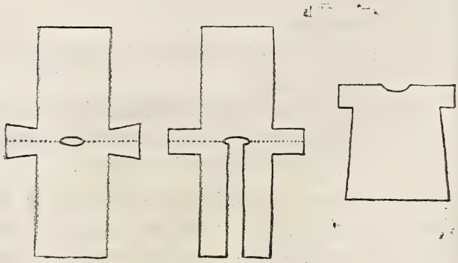
By Alan S. Cole.

Lecture II.—Delivered January 28th, 1889.

I attempted last Monday evening to convey to you an impression of circumstances which might account for the appearance at Akhmîm of a number of woven and embroidered textiles of Græco-Roman, Persian, and Christian character. This evening I have to bring

before you representations of these textiles. The greater number of them are merely fragments of costume and cloths; there are, however, a few fairly complete specimens of garments, almost all of which are of the tunic class. Broadly speaking, the tunic has been worn by all historic nations. The dalmatic of the Carlovingian deacon, the tabard of the mediæval herald, the blouse of the French labourer, and the smock frock of the English and Scandinavian countryman, are all survivals of the ancient tunic. In simpler forms we find that it was worn by Egyptians, Assyrians, Greeks, and Romans; and in considering the relationship which the Akhmîm tunics bear to these, I have extracted a few diagrams from Köhler's admirable work on costume, which I now bring before you. The first is a plan of

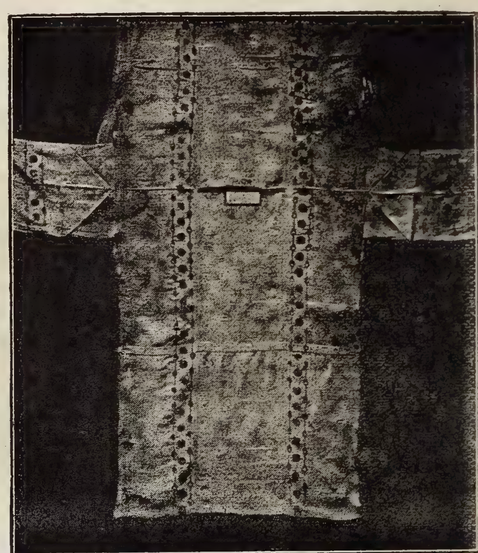
FIG. 1.



Tunic-shaped Garments.

the ancient Egyptian tunic or *kalasiris*, of a period long before the Græco-Roman domination. It consists of a long rectangular piece of material, with a short slit running across its width at the centre of the piece; through this the wearer passed his head. The sleeves are of angular shape, narrower where they would surround the upper part of the arm, and wider where they came round the elbows. Such a tunic was tied in at the waist with a girdle. When a girdle was not to be worn, the garment was shaped so as to be narrower across the breast than at the hem of the skirt. This shaping is noticeable in the Roman short tunic —the third of the diagrams. In that tunic it will be seen that the sleeves are cut square, differing therefore in this respect from the angular sleeves of the old Egyptian *kalasiris*. The second diagram represents the plan of the Hebrew and Syrian tunic robe. It is rectangular in shape, with square sleeves, but the front of the dress opens down to the skirt. Its shape has much in common with that of the Egyptian *kalasiris*. The wearer of such a Hebrew robe put it on by throwing it open and slipping his arms into the sleeves, whereas the wearer of a tunic, which did not open in front, had to pass his head through the hole made for that purpose in the centre of the dress, and then to work his arms into the sleeves. Figures of other varieties of tunic costume might also be produced, but they are virtually included in the three diagrams before us. The Assyrians, 1,000 years B.C., wore rather short square-sleeve tunics, of which many indications occur in such carved stone slabs as are in the British Museum. They are apparently much like the Akhmîm tunics in shape. This is not surprising considering the intercourse which existed between Assyria and Egypt.

FIG. 2.



Linen Tunic from Akhmîm.

Here now is a tunic from Akhmîm. Its sides and sleeves are unstitched. Its sleeves are square like the sleeves of the Assyrian, Hebrew, and Roman tunics. The width being the same throughout, the garment corresponds in this respect with the old Egyptian, Assyrian, and Hebrew tunics, but differs from the Roman tunic; from which it seems that the shape of the Akhmîm dress is more nearly like that of the Assyrian and Hebrew tunics than that of the Roman tunic. And this is of some importance with regard to the dating of the Akhmîm garments. Egyptian, Assyrian, and Hebrew tunics were worn in Egypt before Greek or Roman tunics, so that the develop-

ment of the Akhmîm tunic might be quite independent of influences from Greek or Roman dresses. I lay some stress upon this, because it has been said that the Akhmîm tunics owe their origin chiefly to Roman influence. The ornamentation of them, to which we shall refer directly, certainly exhibits the effect of Roman influence; but it also exhibits, in a similar way, other influences. An instance of how garments of closely similar shape have been made by peoples not brought into directly traceable contact with one another is supplied by Peru. Here is a short tunic jacket with square sleeves. This came from graves at Ancon, which I mentioned at the close of the previous lecture. It was worn by some Peruvian during the Inca Empire. Is it, indeed, an evidence of Asiatic influences which migrating tribes of prehistoric periods

FIG. 3.

Full-sleeved Tunic from Akhmîm.

brought with them when they passed from the Eastern into the Western Hemisphere? And is it, therefore, a descendant of the parent stock to which the Akhmîm tunics are traceable? On the other hand, is it merely an evidence of one of those coincidences occasioned by kindred human wants in nearly corresponding circumstances of climate? Below the Peruvian jacket is a square, sleeveless garment. The hole for the wearer's head is cut in a vertical direction. From Akhmîm we have similar dresses. Here is one of them. The hole for the head is cut horizontally, or across the width. This, again, is a survival of an ancient Egyptian jerkin, and scarcely an adaptation from a Roman dress. The Hebrews and Syrians also wore a dress of the same sort, but rather longer. They used it as an over-covering, and it was open at the sides.

The question of the varieties of such dresses with and without sleeves, which were worn by the different nationalities, Hebrews, Syrians, Greeks, and Romans, who inhabited Egypt at the periods with which we are concerned is, as may be well imagined, a very wide one.

Some of the ampler and fuller sleeved tunics from Akhmîm are remarkably like those worn by Romans in the 3rd and 4th centuries. But whether they were introduced as Martial might have said from the land of Memphis into Rome, or, as seems to be less reasonable, from Rome into Egypt, I will not attempt to decide. The full-sleeve long tunic from Akhmîm now before us finds its fellow in a wall painting of the 3rd or 4th century, from the catacombs of St. Callixtus, at Rome. Here is a photograph of that painting. It displays a woman with uplifted hands in the act of prayer. She is an early Christian, and this

FIG. 4.

Figure of a Christian weaving a full-sleeved Tunic—from the Catacombs of St. Callixtus, Rome.

suggests the thought whether her robe has any ecclesiastical significance. Is it an early type of dalmatic as sometimes worn by the laity? And if it be one, was the Akhmîm specimen also a dalmatic used by a Christian Copt.

Mr. Butler, in his book on "Ancient Coptic Churches," writes that he has been "unable to find any evidence, pictorial or written, for the use in olden times by the Copts of the dalmatic with stripes or *clavi*." The Copts he is speaking of were Christian Copts. Many, as was mentioned in the previous lecture, dwelt in monasteries of Upper Egypt, at Akhmîm and elsewhere. They were, to a considerable extent, affected by the practices and doctrines of the parent Church at Rome, though in certain church matters they took the lead, or, at any

rate asserted an independence. The fathers of the Roman Church ruled that simple white garments alone should be used by the faithful. But through the inclinations of individual Christians, and no doubt, too, through the fashion of Pagan Romans amongst whom they lived, the rule was not strictly kept, for St. Jerome in the 4th century exhorts Christians not to make their linen tunics into precious robes; and elsewhere he deprecates the extravagance of the Roman Pagans in using costly decorated costumes. However, it was of this period that the importation from Alexandria of garments enriched with "figures of saints" and so forth, is specially mentioned by writers of the time. And probably to such dresses as had decorations of religious significance the later ritual of the Church is distantly indebted for its gorgeous copes, chasubles, and dalmatics.

The ornamental garments from Alexandria lead us to the consideration of those from Akhmîm; and for this purpose I have selected three differently decorated tunics, which I fancy mark changes of fashion that occurred during three or four hundred years at least.

The first is a tunic with bands, or *clavi*—of ornament consisting of animals—passing from the shoulders down the length of the dress, back and front. Close to the neck between the bands is a wider band figured of Ethiopian or Arabian soldiery. Each has a shield in his left hand. The two end ones seem to be in the act of throwing, the second holds a leafy stick, the third a sword or stick. All have uplifted heads. A corresponding short band of figures is on the back of the tunic. This is surely a secular and not a religious dress. At the centre of one shoulder-band is a four-petalled blossom, and the corresponding device in the other shoulder-band is a cross; but it does not therefore follow that this cross has a Christian significance. Crosses of various shapes were used as ornamental devices long before Christianity was preached. Here is half of another tunic. Besides shoulder-bands, running down the entire length of the garment, breast, and cuff ornaments, we see on the shoulder a square and another smaller one near the bottom of the skirt on the left hand. Similar squares were inwrought at the other corresponding portions of this tunic. Such squares in Roman and Byzantine tunics were called *tabulæ adjunctæ*. But I have not been able to find evidence that the tunic makers of Akhmîm may not have introduced such *tabulæ* in their garments as early as the 1st century. They mark a fresh fashion in the decoration of tunics, and so far as the Romans and Byzantines are concerned, they were in use as early as the 4th century and as late as the 10th century. Paintings at Pompeii supply us with instances of the tunics with shoulder-bands only, and without *tabulæ adjuuctæ*. As these paintings are of the 1st century it seems pretty obvious that the *tabulæ adjunctæ* were not adopted by the Romans at that time. Towards the centre of the breast ornament in this specimen is a Coptic cross, similar to such

FIG. 5.

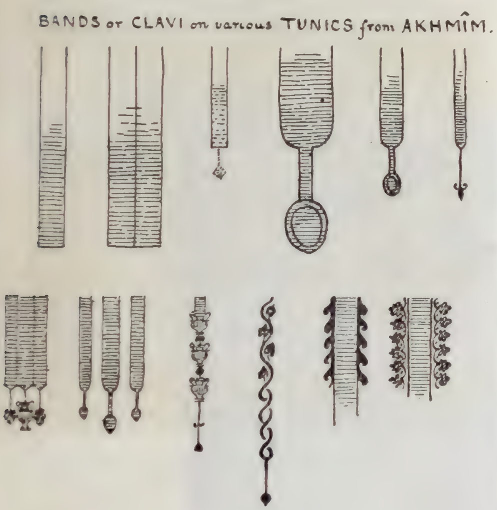
Akhmîm Tunic with Bands or *Clavi*.

as in other ornamental works of art date from the 4th century. Whilst the arcades, the pose of the grotesquely drawn figures forming the breast ornament, and the acanthus scrolls on the sleeves are Roman in general character, the group in the lower square of the skirt is adapted from an earlier type of design. Later on I will show a larger diagram of this group, and leave my remarks upon it until then. This tunic, however, seems to be a secular rather than an ecclesiastical one.

We now pass to a third well-marked type of tunic decoration. Oddly enough, almost all the specimens which belong to this type are the worst preserved and most decayed. In the present one we find that the shoulder

bands or *clavi* are short. They reach barely more than halfway down the dress. They are rounded at the ends, and terminate in pendant ovals. This is characteristic of Syrian decoration to such robes. There is no specially designed breast border between the *clavi*. Instead of squares on the shoulders and at the skirts there are circular panels. The Romans also in the 3rd and 4th centuries used circular panels, calling them *caliculæ*. Many of the subjects woven in the circular panels and in bands, of the same shape as that of these on this tunic, are distinctly of Christian saints; especially of the Coptic Church, like St. George, St. Paul of Thebes, St. Christopher, and St. Demetrius who are figured in various fragments. Hence it is likely that a specimen of this class dates from between the 6th and 8th centuries. Such subjects are therefore quite distinct from the pagan and Roman types of decoration.

Fig. 6.



Bands, squares, circular panels, together with other devices having a variety of shapes, were also used upon cloths or wrappers. With the view of giving some notion of their variety, I have made some rough sketches of a selection from them. Amongst them I have included those with which we are already acquainted.

The first is the square-ended band, next to it a double square-ended band, and then a short square-ended band with a little diamond-shaped pendant. The next three are round-ended bands with oval pendants, and a very narrow little band of this type, but with a pendant trefoil device. Below are varieties of triple bands, the first set close together, having vases as pendants; in the second set the bands are separated. This sort of treatment is common with the robes of Arabs in Palestine. Next to these we have bands composed of ornament such as a series of classic vases, and scrolls with and without ivy leaves, all classical in style. The last are examples of bands with ornamental edgings to them. I ask you to notice the last but one of these two bands. We find in a painting of the 3rd century, from the catacombs of Rome, very similar bands on the robe of a Christian saint in the act of prayer.

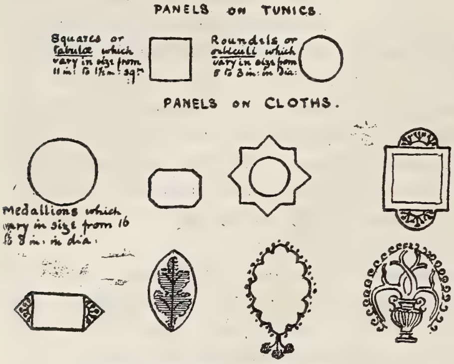
Another catacomb painting, partially destroyed, gives us the figure of a man praying—an *orante*—and clad in a long-sleeved tunic—the *tunica manicata*. Upon this are two short *clavi* with angular ends, terminating in balls. These short *clavi* remind us of those on Christian Coptic tunics. Besides his tunic the figure is wearing an over-cloak.

Although the catacomb wall paintings of the 3rd and 4th centuries supply the greater number of instances of fashion in wearing pairs of bands or *clavi* upon tunics, it may be useful to remind you that the Roman tunic was, from the times of the kings, 7th century, B.C., decorated with a single broad band or *clavus*, a *latus clavus*, running down the centre of the dress. A good deal later a fashion for narrower bands arose; the narrow bands were called *angusti clavi*, and apparently were always worn in pairs as we have seen. It seems, however, that this style of *clavi* was adopted from very early Oriental costume.

Leaving the bands, we come now to a diagram of shapes of panels on tunics, and on cloths or wrappers. The squares for tunics vary in size on the Akhmîm specimens from 11 in. to $1\frac{1}{2}$ in. square; the circular panels, roundels, *caliculæ*, or *orbiculi*, vary from 5 in. to 3 in. in diameter. The simple circular panels on cloths were often much larger; some were as much as 16 in. in diameter. Then there are octagonal shapes, and star figures with a central circle. This particular form of star abounds in Saracenic tiles and wood-work, formerly so common in Cairo. In its application to textile stuffs, it seems to be some centuries earlier than when used by Saracens in Cairo for tiles and wood-work. The remaining shapes of panels on the diagram are merely suggestive of the great

variety of such things amongst the Akhmîm weavings. We shall have occasion to refer to some of them singly; but before doing so, I wish to bring before you a few further instances

FIG. 7.



Panels from Akhmîm tunics and cloths.

of the use by Romans of decorated robes in which occur certain details similar to those from Akhmîm.

The youth praying is from the catacomb of St. Soteris at Rome, and was painted in the 4th century. Upon the skirt of his tunic are two roundels or *caliculæ*.

Here is a piece of beaten metal work of the 4th century; it is part of a silver disc some 18 in. in diameter. The subject represented in the whole disc is the Emperor Theodosius appointing a magistrate. On the right of the emperor is his son Arcadius; on his left his son Honorius. The portion of the disc which I have had photographed, on account of the details of costume shown in it, only gives us Arcadius seated in state. He wears a long-sleeved tunic, and on his left shoulder can be seen the indications of an ornamental circular panel, or *orbiculus*. On his breast is a short pointed band; on the lower part of his toga, or cloak, is a large rectangular panel, filled in with a pattern of overlapping circles. To his right is seen an extended hand and arm, which belongs to the Emperor Theodosius. The hand is delivering a scroll or commission of appointment to the newly made magistrate, whose ample cloak is decorated with square panels. At the opening of the cloak we see the magistrate's girdled tunic, and on the skirt of this is a round panel or *calicula*. This interesting piece of late Roman silversmith's work was found some forty years ago in Spain, in Estremadura.

FIG. 8.

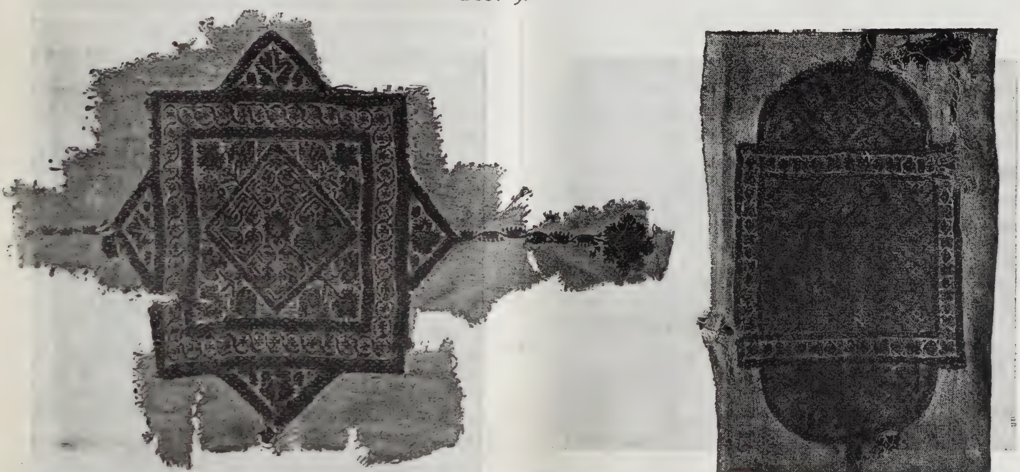
The Empress Theodora and her Court; from the Mosaic at Ravenna.

About 150 years later are the mosaics at Ravenna, designed to the order of the Emperor Justinian by a silversmith — one Julianus Argentarius. A portion of the mosaic displaying the Empress Theodora and her Court, is now shown. There is much in this which it would be interesting to compare with Akhmîm patterns, but the features to which I must now restrict my remarks are the panels—*tabulæ adjunctæ*—on the robes. The lady on the left hand of the empress wears a cloak, on the corner of which is a star-shape panel with a circular device within it, which is similar to

the star-shape panel previously alluded to. The lady next to her has two *caliculæ*—roundels—upon the skirt of her dress; and a third lady wears a cloak with a square panel on it, and two more ornamented square panels appear upon the skirt of her dress. In these we have authentic examples of Roman costume of the middle of the 6th century, A.D. It seems most probable that the panels, as indeed very much of the other patterns, were wrought by the tapestry-weaving process such as we find was used for the majority of the Akhmîm ornaments.

Hitherto I have kept to the bands and panels of dresses. Those for cloths or wrappers were on a somewhat larger scale. A very considerable number of them are made with purple or brownish wools, with outline patterns wrought in yellow flax threads. Possibly the purple dye used at Akhmîm was similar to the historic dye of Tyre. But long after Tyre had been celebrated for its dye, Greek and other towns became notable for corresponding dyes. Hermione, a town in Argolis, was such a one. Mention was made in the course of the previous lecture of the Egyptian artists, weavers, and handicraftsmen taken captive and sent by Cambyses, about 525 B.C., into Persia. Now Plutarch writes that Alexander, about 170 years after Cambyses, having made himself master of Susa or Shusan, found, in the king's palace, "much treasure, as well as purple of Hermione, worth 5,000 talents, which, though it had been laid up 190 years, retained its freshness." Was this a store of purple weaving produced by the captive Egyptian weavers?

FIG. 9.



Panels of purple wool and white linen from Akhmîm.

The coincidence of date lends itself to support such a suggestion. But leaving this, it is quite certain that much of the purple dye used by the Akhmîm weavers has retained its freshness for over 1200 years. This is attested by the actual specimens shown this evening. The endurance of such purple was famed in Plutarch's time, as he goes on to say that "the reason they assign for this is that the purple wool was combed with honey, and the white with white oil. We are assured, moreover, that specimens of the same kind and age are still to be seen in all their pristine lustre."

These ornamental panels are of purple wool, the white patterning on them being of flax. Both the shapes are of Roman and Oriental character. Here, again, are bands of similar work. The specimen is the half of a cloth or covering such as Greeks, Romans, and others have used to throw over couches or employed as shrouds. The patterns are varied, but are of a character which may have been in vogue for many hundreds of years.

I am now going to deal with certain of the Akhmîm specimens in detail. The extraordinary wealth of materials which I have at my disposal, however, quite precludes me from attempting a systematic classification of the different ornamental devices to be seen in them. Here, for instance, are three specimens of quite an early Roman type, the centre piece particularly. If you refer to wall paintings of the 1st century at Pompeii, you find, amidst the decorations of interiors of houses, squares and medallions containing figures of gods and

goddesses. Some—as, for instance, those of Orpheus and Paris—wear circular *nimbi* corresponding with that around the head of this Hermes. He is here represented with a purse in one hand and a *caduceus* in the other. His name in Greek characters appears in the upper part of the square panel. This panel was probably a *tabula adjuncta* of a tunic. The small bands on each side of the Hermes are from the cuffs of a tunic. The weaving of the ornament in them is almost daintier than that of the Hermes. The bands on the right contain a series of charmingly-drawn little animals and dancing boys; those on the left are treated like pilasters, with a succession of balanced leafy forms springing from a basket —a stem terminated with a pomegranate, a snake twisting around it, and at the upper end

FIG. 10.

Pair of cuff bands and square panel of Roman design from Akhmîm Tunics.

a duck. Such emblems and devices are more Roman than Oriental, and for this reason I should fancy that they were designed for the Akhmîm weavers previously to the 3rd century, at which time the Syrian and Oriental influence became more predominant generally.

I will now show you a copy of a Roman mosaic found at Constantine, in Algeria, belonging probably to the 1st or 2nd century. Neptune and Amphitrite in a chariot drawn by seahorses, with two winged cupids holding a fluttering scarf above them are here represented. We find a somewhat similar disposition of figures in the *calicula*, or roundel from an Akhmîm tunic. But the weaver's rendering is not so clearly defined as the mosaics. In this we have a god and a goddess in a car drawn by centaurs. On each side of the god and goddess is a dancing figure, one holding a cup, the other apparently beating a drum with her hand.

Here is another specimen of similar style. It is a square panel from a tunic, and the planning of the ornament is quite in accord with that adopted in Roman mosaics. The central square is set with a circle surrounding a horseman. The border contains four women, holding scarfs which float over their heads, between them are chimerical beasts with fish tails.

The horseman or hunter seems to have been a favourite subject with the Akhmîm weavers.

FIG. 11.

Panel of Roman design from an Akhmîm tunic.

It was possibly in use with them as early as the 2nd century A.D., and survived to a still later period. It also frequently appears as the central group of a pattern set out upon a Roman plan. Here is a specimen of such. In the central medallion is an archer, beneath the legs of his prancing horse a long-eared dog. At each corner of the square is a roundel. Two at opposite corners each contain a little kneeling figure, one with a duck and the other with a hare or long-eared dog; the other two corners —roundels—each contain a kneeling figure, helmeted, bearing a circular shield, both apparently in the act of throwing something. Between these four corner roundels are four baskets of old classic form, which complete

the balance of ornament so characteristic in this type of pattern.

On another slide I have two other varieties of horsemen. One is set in a circular panel; He is riding swiftly, and stretches out his right hand. This figure is woven in brown wools picked out with yellow flax threads. The second specimen shows us a rider in a similar attitude, but his horse is walking gently. This later panel is from a tunic and is of extraordinarily fine texture, in which respect it is one of the most delicate of all the Akhmîm weavings; so small are the threads that they might easily be mistaken for silken ones, and not, as they actually are, flaxen and woollen. The ground generally is greenish blue; the horse is white, its trappings and the rider's boot are red. The square border to the circular centre is treated after the manner of Roman mosaics with fishes, birds, and fruits, amongst which last is a pomegranate. The panel beneath is about one and quarter inch square, probably a *tabula* from an infant's tunic; it is equally delicate in texture, and is wrought in "purple wool" and flax threads. The horse and rider is a class of subject analogous to such as delighted Sidonius Appolinaris, who enthusiastically describes Persian stuffs imported at his time (5th century) into Europe. He writes:—"Bring forth brilliant cushions and stuffs . . . on which, produced by a miracle of art, we behold the fierce Parthian, with his head turned back, on a prancing steed; now escaping, now returning, to hurl his spear; by turns fleeing from and putting to flight wild animals whom he pursues." Exactly the same kind of subject is reproduced on some pieces of Græco-Scythic goldsmiths' work found in the Crimea. These relics of a semi-barbarous art are now preserved in the Hermitage at St. Petersburg. They probably date from the 3rd century B.C.

This next diagram is taken from what remains of a Roman glass disc ornamented with gold work. A large roundel with the head, perhaps of St. Paul, occupies the centre, whilst at each corner was a smaller medallion containing heads. The intervening space is filled with a scale ornament. This is one of those rare specimens of glass found in the catacombs and now preserved in the Christian Museum at Rome. Again, the planning of the ornament is very similar to that of a square from an Akhmîm tunic. Here we have a large central roundel with a chimerical beast, and at each corner a small roundel containing a head. Between them are lunette or semicircular devices; the edge is of classic wave pattern.

From Barcelona in Spain, and probably of the 3rd century, we have one of a number of mosaics found there. The subject I have selected is that of an ostrich surrounded by a laurel wreath.

On turning to Akhmîm, we find there a coloured weaving of precisely similar intention in decoration. Instead of an ostrich, however, we find a duck surrounded by a wreath. The colours in this specimen are remarkably brilliant, and the representation of the bird successfully given.

FIG. 12.

Panel of Roman design from Akhmîm tunic.

From old time the Egyptians were skilled in depicting birds. The two before us were painted on walls at Thebes, 2,000 B.C. Under Roman influence the Egyptians seem to have shown that they inherited some of the skill of their forefathers in this branch of depicting natural forms. Two more specimens of their bird drawing are to be seen in these two panels; that on the left is admirably preserved, it is of somewhat stouter weaving than that on the right, which has been so unfortunately torn; enough, however, remains of it for us to see the excellent skill in rendering the head, breast, and a claw of what must be a quail.

Few specimens of Akhmîm tapestry weav-

ings supply us with Egyptian patterns or ornament represented in the conventional Egyptian manner. In the collection at South Kensington there is a heavy-looking *ankh* or *crux ansata*, the upper portion of which is circular instead of being pear shaped, whilst the *tau* cross is relatively disproportionate. Another piece of Akhmîm work, the ornament from the breast of a tunic, which I now show, contains three flowers resembling certain representations in Egyptian paintings of the lotus flower. On the other hand, the adjacent little figure of a warrior bearing a shield does not suggest Egyptian treatment; it possibly is intended for an Ethiopian or Arab soldier such as was doubtlesss to be frequently seen at Akhmîm before Diocletian came up the Nile to destroy many towns, including Coptos, for the purpose of checking the rising power of Ethiopians and Arabs. If this be so, the ornament would probably have been made about the 2nd or 3rd century, A.D.

Upon comparing ornamental works, produced in different countries and at various times, with one another, we are often struck with some likeness which brings them into relationship with one another either as regards subject or arrangement of details. This leads us to suppose, and sometimes rightly so, that the designers and art workmen of different nations have copied each other's works. We may therefore form a succession of kindred specimens exhibiting similar features, and thereby establish and demonstrate a theory of perpetuation or survival. In some cases no doubt the theory may have been pressed absurdly, and this perhaps is more frequently the case where the latest version in a theoretically successive series is seen to be quite different from its assumed origin. On the other hand, a design may have been produced by an artist of great skill working for patrons having very cultivated perceptions. Such a design copied and re-copied may be found to have percolated into a country where a much lower standard of skill and perception existed. The version of the design producible in this latter country would be comparatively debased and barbaric. When history very distinctly proves that the highly and the less cultivated countries have come into contact with one another, the truth of the perpetuation or survival is established. The same remarks apply in respect of epochs of time respectively marked by rises and falls in artistic skill and perception. I have ventured to make these remarks as prefatory to bringing before you a few examples of Akhmîm textiles, the designs of which appear to be survivals of the same or similar groups of men and animals, and of the same or similar styles of treatment previously produced and adopted in other countries or at earlier times.

The first of these examples is of a man fighting a lion. A dignified rendering of this subject occurs in a sculpture, probably of the 6th century B.C., from Persepolis. This is said to represent Xerxes, or some Persian monarch, stabbing a lion. It is the work of some of the many skilled sculptors who were employed upon the erection of the palace there. The king has seized the rearing lion by a tuft on his head, and is stabbing him with a sword. The rectangular space that this group adorned naturally affected the designer in the composition and arrangement of the group. From Akhmîm we have a circular ornament from a tunic, and a circular space would necessarily modify the arrangement of a corresponding group of figures if such were placed within it. In the centre of this rosette we see a rude design of a wild-looking man running a lion through with a spear. Thus, whilst there is some likeness between the subjects of these two specimens, there is a very wide difference between the two representations of the subject, not only in regard to pose and details, but also in treatment. How far, if at all, the Akhmîm designer was indebted to a percolation from Persia of the sculptured lion slayer I do not pretend to say. History, however, has told us of the constant communication in past ages which Egypt had with Persia.

Again, amongst the ruins at Persepolis is a group of a lion springing on to the back of a species of horse. A few centuries later in date, less naturalistically pourtrayed and of uncultured conventionality, is a piece of beaten gold work which was found at Kertch in the Crimea, and is classified as being of Græco-Scythic workmanship. It is perhaps the tip of a sword scabbard or of a quiver for arrows. Here we have a lion, after the nature of such beasts, attacking a stag, having pinned him at the back of his neck. A square panel from an Akhmîm tunic supplies us with a panther similarly seizing a long-horned goat, or ibex. The arrangement of the groups in each of these instances is alike. It is, however, one which would be obvious to any designer living in a country where savage animals abound and prey upon weaker ones. The representa-

tions of it, therefore, may have no relations to one another such as might link them together as types of a series sprung from a single source.

Amongst the wall-paintings of Beni Hassan, some 2,000 B.C., is the representation of a fig-tree, with monkeys in it picking the fruit. The formal shape of the tree is peculiar, and suggests a comparison with an Akhmîm design of probably 2,300 years later. Are the two shapes, in which the spreading branches are so arranged as to produce very similar ornamental effects, merely coincidences? In the Akhmîm design we have a tree shooting up from a vase of classic form and decoration. A grotesque female figure stands in the forked main trunk or stem; lower down near the lip of the vase are two birds, one on each side of the stem. By the side of this vase and vine is a pointed oval shape—a panel from a wrapper, composed of a similar formal arrangement of a vine.

Processions of animals were wrought by Assyrian metal engravers upon metal plates or plateaux, such as are in the British Museum. Somewhat analogous to these are bands of animals painted upon early Greek and Etruscan vases. To some extent the decorative intention in thus using animals appears in Akhmîm patterns. The two bands now shown are woven in brown worsteds upon a tunic. There are certainly lions amongst these animals, and probably dogs, hares, and ibexes. The lions occur the more often (I would ask you to notice the shape of the lion's manes). Does the frequent occurrence of the lion in such a pattern illustrate the effect upon a designer of the hunting exploits told of such Egyptian monarchs as Amenophis III. (18th dynasty), who for ten years hunted lions in the Mesopotamian plains, killing 102 of them with his own hand, and subsequently marrying a daughter of his host, the King of Mesopotamia?

In the 10th and 11th centuries ivory carvers converted elephants tusks into oliphants, or hunting horns, enriching them with representations of animals. Here we have two views of the same horn, or oliphant. The carving is usually called Byzantine, but this is not, of course, to be taken as meaning that the carvers practised their art in Byzantium or Constantinople only. Byzantine influence extended to Egypt, and as much of the ivory from India and elsewhere passed through Alexandria for Europe, some of the carving on it may have been done there.

There is, I think, some likeness in style between the animals on this horn and those in the Akhmîm specimen, which latter, however, is probably work of the 2nd or 3rd century, and therefore 700 or 800 years earlier in date. And now going back another 800 years earlier still, we may glance at the engraving of a Græco-Assyrian bowl found in Cyprus. Here we have a variety of subjects. Those on the outer border relate to the labours of Hercules, those on the inner border have to do with Egypt, whilst the centre is filled in with some incident of Egyptian warfare. But it is to the peculiar treatment of the lions' manes in the outer border that I wish to direct your attention, on account of its likeness to that of the same details in the Akhmîm specimen.

A representation of Rameses II. about to slay a kneeling captive whose hair he grasps, occurs in an Egyptian wall-painting done 800 years earlier than the Cyprus bowl. The similarity between this group and that in the centre of the Cyprus bowl is obvious.

And now turning to a square panel formerly on an Akhmîm cloth, we have another version of such a subject. The group here consists of a man slaying a captive; the man, armed with a short naked sword, wears a blue Phrygian cap and red scarf; he is holding the hair of his victim. This latter seems to be dressed in a tunic spotted with circles. Do these represent chain armour or are they merely a pattern? Is the incident one of a Roman or a Palmyrene slaying a Persian—as indeed freely happened in the 3rd century A.D., during the war waged against the Persians, when the Emperor Valerian was taken prisoner by Sapor II., a monarch of the Sassanian dynasty of Persia? or in the group a survival of Egyptian tradition concerning Rameses II.?

The mention of a Sassanian king brings us to a specimen of Akhmîm weaving, in which I think the relationship between Akhmîm, Sassanian, and later Roman, or Roman Byzantine art, can be seen in a more direct and certain manner than that of the previously suggested relationships. The figure before us of a draped angel wearing a diadem or jewelled cap, and holding a wreathed cross, was evidently one of a pair. It measures about 2 ft. 3 in. long from the centre of the wreath to the feet of the angel, so that the two figures, as originally woven, would have covered a space of 4 ft. 6 in. A device of this size was for use on some cloth or hanging, and looking to its religious symbolism, the group was no doubt used on a church hanging, probably an altar cloth in some Christian

Coptic church of the 4th or 5th centuries. But it was in use in Rome in Trajan's time, as the angels upon the pedestal of his great column testify. Similar figures also occur in the spandrels of the arch to

FIG. 13.

Figure of an angel woven in coloured worsted and flax threads from Akhmîm.

the rock sculptures at Kermanchah, about sixty miles north of Bagdad, in Persia. These sculptures are of Sassanian or Perso-Roman style, and are commonly known as the "Throne of Rustem." They are probably almost contemporary with the Akhmîm

FIG. 14.

Diagram of Sassanian sculptures at Kermanchah, Persia

angel. The winged females in them have the same pose as the Akhmîm angel. They wear the same same sort of jewelled head-dress or diadem. Each, however, in her right hand holds a wreath, and a cup in her left, details having no Christian significance, and not seen in the Akhmîm specimen. Between the two figures is the crescent, an emblem in solar and fire worship, also of Ashtaroth, and adopted later on by Mohammedans as a symbol. Similar in pose and arrangement to the Akhmîm angel are two carved upon a Roman-Byzantine ivory diptych of the 6th century, the original of which is in the Public Museum at Ravenna. The subjects on the lower portion of the diptych (not here shown) are Christian. As might be supposed, even were this ivory specimen not before us, the treatment of the figures, drapery and wings, is more delicate and artistically complete than that of either the Akhmîm or the Sassanian specimens.

When, at an earlier part of this lecture, we considered the tunics and their decoration, I referred to the bands of ornament wrought into the cuffs. There is a considerable variety of them. But as they consist almost entirely of waved leafy stems I do not propose to make many remarks upon them in detail. I have selected a few as examples, and will pass them rapidly before you, together with bands of similar patterns, but of rather larger dimensions, which were used on cloths.

Beginning with three of the broader bands for cloths we have patterns such as these. The first is a single continuous waved stem with vine leaves and bunches of grapes, placed between the wavings of the stem. The next to it consists of two waved stems, with vine leaves and tendrils, divided by a straight stem. The third is of a more open-waved stem, with a pair of leaves, perhaps fig leaves, placed in each wave.

In another series, which is of cuff bands, we have bands in pairs. The first is small in pattern and formal in style of ornament. The middle one is made up of a series of repeated single vine leaves on a thick stem with one or two grapes. The last one is of a continuous waved stem of vine leaves. This is bordered on each side with an edging of little stem and ball devices.

The last of the cuff bands contains double bands of continuous and waved ivy stem pattern, which is much in the style of such favourite classic patterns. The second pair of bands is ornamented with a number of *amphora* shaped vases, of a Roman character. The third small band has a single continuous waved stem with alternate trefoils and bunches of berries.

In making up my notes for this lecture I intended to have touched upon the Christian

symbols to be seen in some of the Akhmîm specimens. But this branch of the subject is a large one, although the specimens themselves may not be very numerous. Of course the vine and grapes might be claimed as Christian emblems. On the other hand, long before Christianity reached Upper Egypt the vine had been cultivated there, and a waved stem, with leaves and fruits springing from it was a device often used for ornamental bands and borders by Greeks and Romans. So that patterns of like construction with vine leaves are not by any means to be taken as necessarily implying Christian influence in their production. The whale which occurs in Roman-Christian sculptures and wall-paintings in connection with Jonah as typifying the Resurrection, was also woven sometimes at Akhmîm. But the more distinctly Christian designs from Akhmîm are such as contain figures with uplifted hands, which I think must be accepted as *orantes* of Christian meaning. In other pieces we meet with figures of saints which, as I have said, have been identified as St. George, St. Paul of Thebes, St. Christopher, St. Demetrius, and so forth. There seems to be no doubt about these. The rendering, however, of these Christian subjects is, as a rule, barbaric, and cannot compare with that of the Roman designs, or of those which appear to have a Persian or Syrian source. Two of such quaintly barbarous pieces I have selected, and now place before you. The colours of the worsteds are bright; scarlet and crimson predominate in the left-hand specimen. That on the right is rather sombre in tone, although the blues and greens are vivid. Both are parts of tunic bands, comparatively short bands with rounded ends, reaching to about the waist of the dress. This form of band we noted as being apparently of a later date altogether than that of those having Græco-Roman patterns. The principal figure in the band on the left is of a woman with a *nimbus* about her head; she is richly robed, and carries in her right hand a sort of floral staff, or it may be a *flabellum*. Beneath her left hand, which points upwards, is the rudely-drawn figure of a little child. It is thought that the two represent the Virgin and Child. Above them are two groups of people; the upper one of all may illustrate the miracle of making the blind to see, as one of the figures is raising his hand to the face of the man next him. The lower group is possibly intended for making the dumb to speak or the deaf to hear. Below the Virgin and child are other figures, the first set of which may be for the making of the lame to walk; one figure gesticulates to another who is leaning on a stick. The lowest group of figures may perhaps be meant for dumb persons who have recovered the use of their tongues, to which two of them seem to be pointing. The only parallel to this style of debased drawing that occurs to me is that of Coptic missal illumination, a small specimen of which is in the South Kensington Museum. The figures in the

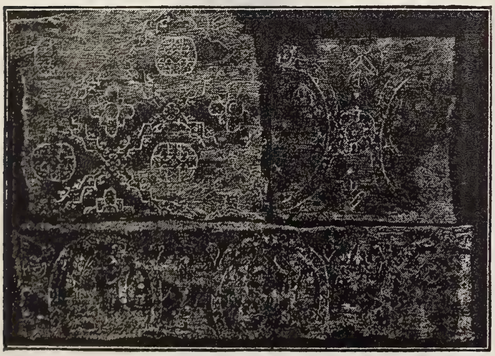
FIG. 15.

Band or *clavus* of Coptic design from Akhmîm.

second band are rather more distinct; the central one is a Christian, in a tunic and cloak, in act of prayer, with both hands uplifted in accordance with the attitude which prevailed with Christians of the 3rd and 5th centuries. Below the praying Christian is a device something like a hive with ears. This I believe to be intended for a temple, for the upper part of it rests upon two pillars. The earlike excrescences from the roof are, it is suggested by a friend, possibly intended for the pointed constructions erected on Egyptian buildings of all periods, to catch the wind and convey it into the interiors. They are called *mulqufs*. In the edgings to both pieces will be seen a succession of petal forms or buds. This is an ornament which occurs in the 6th century wall mosaics at Ravenna and at Rome.

The circular panels which adorned the tunics with short rounded shoulder bands are equally rude in design. Here are two of them. In the left-hand one we find four figures holding scarfs above their heads; between them are temples—the construction and details of which are more clearly shown here than in the band on the previous slide. The little device in front of the temple seems to be meant for a tree. The right-hand panel, of which only half remains more or less intact, contains the familiar group of a horseman with his dog and the animal he is hunting. This is repeated in reverse. Ornament of this class is to be seen in silken specimens from Alexandria of the 8th and 9th century. Anastasius Bibliothecarius, the librarian of the Vatican, in the 9th century, and author of the *Liber Pontificalis*, describes the patterns woven in such silks over and over again. A distinctive feature in them was a series of circles, each one containing either a bird or an animal, flowers or trees, men on horseback, swords, &c. For instance in his "Lives of the Popes," Anastasius writes of stuffs figured with men and horses, "*Homines et caballos*," and describes a dress with wheels or circular panels and men, "*Vestem cum rotis, et hominibus*," &c. It is probably from such that Akhmîm tapestry-weavers at this period took many of their designs.

Fig. 16.



Examples of these are given in bits of Akhmîm weaving done in much larger pieces than those of the Græco-Roman and Persian type. The upper right-hand specimen in this slide gives us a portion of a large weaving, the pattern of which consisted of a series of large and small circular bands filled in with floral ornament. The employment of repeated circular bands or medallions has been referred to, and this type of pattern was very greatly in vogue for costumes and ornaments classed as Byzantine, from the 8th to the 12th centuries. We have another version of it in the lower long strip, the panels being pairs of mounted archers, a device which carries us back to Persia. On the upper left of the slide we have a sort of trellis pattern, and within the diamonds or squares are medallions and the very favourite quatrefoil and square device of Byzantine ornament; whence, therefore, we may conclude that all these last Akhmim specimens were woven about the 8th to the 10th centuries.

This concludes the series of varied designs which I have selected to bring before you. I feel that I have attempted to crowd too much into this second lecture, and that I have taxed your patience too far. In these circumstances I can hardly venture to encroach further upon your time. Summing up in the fewest words, I may perhaps say that the Akhmîm designs seem to be capable of classification into groups which display typical ornaments from the 2nd century A.D. to the 10th century. There may be a few which point to a still earlier date. Looking to the numerous different foreign influences which passed over Akhmîm, in common with the whole of Egypt, there appears to be no reason why such should not be the case. The mere process of tapestry or comb-weaving dates, as we have seen, from the 3rd and 4th centuries, B.C., and it is principally by that process that most of the specimens were woven.

I may be allowed to draw your attention to the capital coloured *fac-similes* which have been published by Mr. Griggs for the Department of Science and Art. I hope to continue my inquiries about these most valuable links in the history of ornamental art with which we have been concerned. I shall very greatly value any assistance which may be given to me in this direction, as I feel that at present I have scarcely done more than touch the outskirts of a subject which is intermingled with an enormous number of incidents and conditions connected with a long period of time.

Miscellaneous.

LONDON LAUNDRIES.

In the "Notes on Previous Enquiries," issued by the Society in connection with the National Water Supply Congress of 1878, there were reprinted (Appendix, pp. xi. to xxiv.) several references to

washing, from reports which, being long out of print, are not readily accessible. In an extract from the 1850 report of the General Board of Health (p. xix), it will be seen that the total cost of the "washing bills" of London was calculated to be about five million pounds per annum. This included the cost of home washing as well as the bills paid to laundry establishments. Since 1850, London has immensely increased, but what the total washing expenditure is now has not been estimated. Against the increase of population must be considered the decrease in the cost of the materials used in washing. Still, though this may affect artisans, labourers, &c., who have their washing done at home, laundry establishments are costly to maintain, and their charges show no decrease, for in large establishments, in addition to materials, labour, and the cost of maintenance, there is the cost of collecting, delivering, sorting, and checking books. Whatever may be the correct statement as to the total amount annually paid to the large laundries, now so numerous, it has to be reckoned in hundreds of thousands. With such large sums available, the modern development of the laundry with steam power, heated drying compartments, and extensive covered drying grounds is no marvel. There does not, however, appear to be any history* of the development of the industry, though now so extensive.

Nor does there seem, from inquiries, to be any uniformity in the methods and customs of different establishments.

Washing is as much a chemical process as dyeing, or pattern printing, and, viewed chemically, there are many analogies between them. Both are, indeed, a series of processes. Though in a first-class laundry the final "get up" is held to be a matter of importance, and good clear-starchers and ironers receive slightly better wages (sometimes much higher) than those who attend to the other processes, and the mangle is under the direction of people of experience, the really important processes, regarded from a sanitary point of view, are the actual cleansing (itself three distinct processes, "digesting" or soaking being first, washing second, and rinsing third) and then the "drying," as it is called; though the "drying" process, as formerly conducted everywhere, and still carried out in the country, means much more than simply drying.

In modern laundries the actual cleansing may or may not, according to the custom followed, be effectual. There are two totally distinct points to be kept in view in this process—the two sources of "soiling," which are quite separate in their origin. There is the dirt that comes from without and settles on clothes and the textile fabrics of all furniture, whether washable or not, just as it settles on wood and metal work. In the country this approaches *nil*, but in towns it consists of smuts, smoke, and dust from sources that are unpleasant to contemplate. And there is also the "soiling"—perhaps not appreciated by the eye—which comes from the skin, if in a healthy condition for performing its proper functions. Far short of that visible result of activity to which rightly the old word sweat is applied, there is the continuous invisible perspiration (though the word is so misused), and it is this, whether given off from the skin rapidly and visibly, or slowly and invisibly, that "soils" under-clothing which but slightly is affected by dust or dirt. It is this result of healthy skin action that it is more important to thoroughly remove.*

However far this may be done or not in the processes of washing, there has been a growing belief among chemists who have studied ozone, that this removal is helped, in a greater or less degree, according to the conditions of the atmosphere, by the process commonly regarded as drying, when the drying is conducted in the old-fashioned way in the open air. Country people judge much of the thoroughness of a washing by whether the clothes smell "sweet" or not. They probably know next to nothing about oxygen, and very likely have never heard of ozone. They go by experience. But though no chemist has directly applied his researches to the processes of washing, the inference to be drawn from all the investigations about ozone is that the process of "drying" is, in addition to getting rid of moisture, a chemical one, sometimes feeble, sometimes powerful.

Perfect though the washing of laundries may be, it seems that in the drying they, by their present arrangements of heated drying-closets, lose some of the advantages of the older and, in the country, still prevalent custom. The chemical action of light is lost, and the ozonising effect is lost.

Though dyeing has long been recognised as a branch of science, and has its extensive literature in several European languages, washing is not yet so recognised. In the country it has been, like jam-making, a purely domestic matter regulated by experience. No sanitary hand-book, or laws of health, or "domestic economy," touches on the subject.† It has not yet found a place in ordinary technical education. It has become detached from the old-fashioned household management as much as brewing, baking, pickling, or preserving fruits; yet it has no books of instruction as to its principles. Neither Watts's "Dictionary of Chemistry," nor Frémy's Encyclopædia, nor the large German works bestow any attention on it.

There has, however, been a vast amount of research work that seems to bear on the chemistry of washing and "drying," yet it has not been so expounded that those who have control of laundries can readily

* No standard books of reference, such as the "Encyclopedia Britannica," even give the word laundry or wash-house. If there be any special work on the subject, it has escaped notice in a search specially made through catalogues.

* Unhealthy skin action is a form of "disease," and the clothes of people suffering from any disease should never be sent with other linen to a laundry. It should be specially notified.

† Parkes, Wilson, Corfield, and others, make no allusion.

profit by it. For there are fixed natural laws—which for convenience are called chemical—laws always acting in the processes of washing, though laundry work, not being yet a technical subject, is not a recognised branch of applied science. As a fact, and perhaps as a consequence of want of scientific consideration, while all sorts of practical experiments have been made in the washing processes of laundry work, little attention seems to have been paid to secure in artificial drying all the natural conditions of open-air drying.

The real value of these practical experiments is very varied, just as the processes vary. Many people are able to see as the result of some of them that linen, lawn, and calico wear away more rapidly than with country washing. Dr. Clarke (see "Notes on Previous Enquiries," appendix p. xiii.) attributed this, in the case of London, to the hard water, and quotes the case of two brothers, one living in Glasgow and one in London, who found such a difference in the rate of wearing out of their shirts.

The opinion of most people, though it is not officially recorded in evidence, seems to be that the rapid wearing out is partly due to the use of sundry ingredients in the washing water, which they roughly group under the name "chemicals," and partly to the use of labour-saving machines.

From a sanitary point of view wearing out has not to be considered so long as thorough cleansing is secured, and whatever the benefits, and whatever the destructiveness of "chemicals," these are not confined to large laundries. Of the real value of all these experiments there is no record.

In "drying," however, there would seem to be a great difference between the results obtained from heated chambers, and drying in the open; though, as regards London itself, the advantages of the open drying are variable, and the best results rare.

Ever since, in 1840, Schönbein recognised ozone as a distinct substance or variety of matter, our knowledge of its function, if not of its origin, has been progressive, though of spasmodic growth. In 1845 Marignac made known his experiments, showing that whatever it was, its action was to produce oxides of other bodies, and he inferred generally that it "oxidised." The work of Soret, de la Rive, and others from then till about 1863, showed it was probably some form of oxygen. The presence of it, as apart from oxygen in the atmosphere was studied, and its influence and periodic occurrence was a subject of a communication by Moffat to the British Association in 1865. The proofs that it is a purifier of organic matter, even to the extent of being an antiseptic, appear established. Oxygen itself, when repeatedly breathed, loses its oxidising influence. This, however, seems clear, that ozone, when present in the air, is a more effective oxidiser than oxygen itself, and that its effect on thrown-off organic matter is most marked. Here with hardly a doubt is the explanation of the "sweetening" effect of drying clothes in air containing ozone. It oxidises up not only what washing has not removed, but also the organic fats of the soap themselves.

In towns the air generally contains little free ozone, though at periods perhaps fixedly recurring, it is abundant. But there are ways of manufacturing ozone; and not only for experiment, but for actual use, machines have been made. Among the most effective are those on the type of Sir William Siemens. They have been made for some sanitoria. Their use in "drying chambers" does not seem to have been yet tried, but from all analogy a very high sanitary effect might be expected.

Many of the London laundries when first instituted were fairly among green fields, and not surrounded by conditions to destroy the efficacy of the ozone that came to them. But encroaching buildings have altered these surroundings. But while this great development of London has been taking place, knowledge has been gained, it is to be hoped, sufficient of how, by machines, to restore, in quantities sufficient for rooms, the ozone that all this growth absorbs and neutralises.

General Notes.

BUENOS AYRES TRAMCARS.—A tramcar line is being constructed in the Argentine Republic which will connect Buenos Ayres with the outlying towns, and will, when finished, extend over 200 miles. The cars will be drawn by horses, which are cheap and plentiful in South America; while fuel, both wood and coal, is scarce and expensive. The rolling stock consists of five sleeping cars of 18 feet long, each with six beds, which, in the day time, are rolled back to form seats; four two-storied carriages, twenty platform carriages, six ice waggons, four cattle trucks, and two hundred goods vans.

MEMORIAL TABLETS.—The *Athenæum* reports that a memorial tablet movement has been started in Newcastle-on-Tyne. Already Bewick's workshop, the birthplace of Lord Collingwood, and the site of the old close-gate, and the lodgings of George Stephenson in Eldon-street, have been indicated by appropriate inscriptions. Tablets have also been affixed to the house on the Sandhill from which Bessie Surtees eloped with John Scott (afterwards Lord Eldon), and to the bookseller's shop at the Grainger-street end of Nelson-street, in which Garibaldi, Kossuth and other distinguished exiles met their local friends when visiting Newcastle under the guidance of Mr. Joseph Cowen. In Redruth, Cornwall, a granite tablet has been fixed upon the end of the house in Cross-street, once occupied by William Murdoch. The inscription is "William Murdoch lived in this house 1782-1798. Made the first locomotive here, and tested it in 1784. Invented gas lighting and used it in this house 1792."

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FRIDAY, SEPTEMBER 20, 1889.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

ART-WORKMANSHIP PRIZES.

The Society of Arts offer the sum of £150 in money prizes, as well as twenty of the Society's Bronze Medals, for objects in the "Arts and Crafts Exhibition" to be held at the New Gallery, Regent-street, from October 7th to December 7th.

Details of the classification, &c., were given in the last number of the *Journal* (September 13th). Further information, together with forms of application, may be obtained from Mr. Ernest Radford, Secretary of the Arts and Crafts Exhibition Society, 44, Great Marlborough-street, London, W.

EXAMINATIONS, 1890.

The subjects of examination are—1. Arithmetic; 2. English (including composition and correspondence, and précis writing); 3. Book-keeping; 4. Commercial Geography; 5. Shorthand; 6. French; 7. German; 8. Italian; 9. Spanish; 10. Portuguese; 11. Russian; 12. Danish; 13. Chinese; 14. Japanese; 15. Political Economy; 16. Domestic Economy; 17. Theory of Music; 18. Practice of Music; 19. Practical Commercial Knowledge.

These examinations will be held on April 14, 15, 16, and 17, with the exception of that in the Practice of Music, which will be held during the week commencing on the 2nd of June.

The Programme is now ready, and copies can be obtained gratis on application to the Secretary.

Proceedings of the Society.

CANTOR LECTURES.

INSTRUMENTS FOR MEASURING RADIANT HEAT.

By C. V. Boys, A.R.S.M., F.R.S.

Lecture I.—Delivered March 25th, 1889.

At the time that I was honoured by the invitation to give a course of Cantor lectures, I was so much absorbed in my experiments on the development of instruments for measuring radiant heat, that I naturally turned to that subject as one which I hoped would be worthy of being discussed in the rooms of the Society of Arts. However, now that the time has come when I have to put before you an account of the different instruments of this class that have been made, and of the principles upon which they depend, I feel, when I consider what splendid courses of Cantor lectures have been delivered in this room, how utterly unable I am to follow in the steps of those that have gone before me, or to treat my subject in the manner that it deserves.

When an ordinary candle burns, heat is developed, which escapes chiefly in the stream of hot air which rises from the flame. This stream is sufficiently powerful to keep a screw of paper at a height of six feet constantly rotating. If there are many candles or lamps, then the number of separate streams unite in a lake of hot air, which may be found resting under the ceiling of the room. Heat escaping in this way is said to escape by convection. If a piece of copper wire is placed with one end in the flame it also becomes hot, and some heat escapes along the wire, so that a ball supported by wax falls when the wax is melted, or a piece of phosphorus catches fire, or the fingers holding the wire are burnt. This passage of heat through a material which it warms is called conduction. Finally, if the finger is held a few inches away from the flame, and about level with it, though no hot air is driven in that direction, the finger clearly feels the sensation of heat. Heat is escaping in all directions from the flame without warming the air round about, and without being sensible until it falls upon some obstruction, when its existence becomes known. This heat escaping by radiation may be felt in

any room in which a group of gas burners is alight. All that is necessary is to take a sheet of tin plate and hold it in such a position as to reflect the light—and therefore the heat—on to the face. If the plate is suitably bent by hand, not only will it be filled with light, but the heat which then falls on the face is evident at distances at which we might think some very delicate apparatus would be necessary to detect it. The heat felt under these conditions travels through air without appreciable absorption, just as light does. The air is not warmed in the process; the energy of the radiation passes on unchanged, and only becomes sensible as heat when it meets with some obstruction. In the case of the sun, no heat can escape by convection, for there is no atmosphere outside it in which currents can be produced. None can escape by conduction, for it does not rest upon anything. All the heat which reaches the earth from the sun, all which leaves the sun at all, is, as far as we know, due to radiation.

The relative amount of heat which escapes from hot bodies by the three processes which have been described — convection, conduction, and radiation — varies very widely but in general, except among the heavenly bodies, the first two between them are far more important factors in the cooling of a body than radiation. The amount of heat which escapes by radiation is freely radiated into all space, so that if the obstructing body is small, or is any considerable distance away, but a small proportion of the radiation falls upon it, the rest, of course, escaping in all directions. For these two reasons instruments which are intended to measure radiant heat, as it is commonly called—or radiant energy, which is a better term—must in general be capable of showing quantities of heat which are very small in comparison with that stored or developed in the radiating body.

These instruments differ from thermometers, in that when a thermometer gives a steady reading temperature is indicated, and there is no heat flowing to or from the thermometer. On the other hand, with instruments for measuring radiant heat, instruments that would be called radiometers if Mr. Crookes had not already given that term a special meaning, the actual temperature of the hot body is but one of the numerous factors which determines the indication of the instrument, and, further, the instrument only gives a steady indication when the rate at which it receives heat from the hot body is equal to the rate at which the part of the instrument heated by the radiation loses heat in consequence of its excess of temperature. At first the exposed part increases in temperature; as it is warmed it loses heat, generally, in all three ways, by conduction, convection, and radiation; this loss becomes faster as the temperature rises, and in time a steady state is arrived at, when the rate at which heat is received is equal to that at which it escapes.

Among instruments for measuring radiant heat I cannot do better than at once refer to the thermometer with a blackened bulb *in vacuo*. This instrument will of course, in time, show the temperature of any enclosure in which it may be placed; it then acts as a thermometer simply, and the vacuum round the bulb merely serves to make the process of acquiring the temperature of the enclosure slower than it would be if the intermediate space were filled with air; or it may be exposed to the sun's rays, in which case, if it did not lose heat at all, it would go on rising in temperature, slowly, possibly, but still without stopping until it acquired the temperature of the sun, or was destroyed in the process. In this instrument everything is done that can be done to reduce the loss of heat. Because the bulb is in a vacuum, convection of heat is prevented; because the bulb is only supported by a slender stem of glass, conduction of heat to the outer world is almost inappreciable. However, radiation remains, and it is this that determines the temperature to which the bulb will rise when exposed to any given source of radiation. Though the rate at which the bulb loses heat at any given temperature would be diminished by silvering it, such a silvered bulb would not become actually hotter, because it would absorb heat more slowly in about the same proportion. The chief advantage that is obtained by the use of the black surface is quickness, for both the gain and the loss go on at a higher rate than would be the case with any other surface, and, therefore, the final or steady state is more rapidly brought about. This instrument would more truly measure the relative heat of the sun's rays if it were fixed in a place having a constant temperature. When it is simply placed out of doors it is impossible to say what the temperature of the surrounding bodies—the ground, the walls, the sky—really is; but, on the whole, the rate at which heat leaves the bulb is greater in winter than in summer, for a given temperature of the bulb, and, therefore, the temperature to which it will rise for a given rate of radiation

is less in winter than in summer. I have referred to this instrument at this stage because it illustrates well the difference between a thermometer, as commonly used, and an instrument for measuring radiant heat. It serves both purposes. It shows the temperature of an enclosure when outside radiation is prevented. By its excess of temperature above that of surrounding bodies it shows at what rate heat is being poured into it from the sun or other radiating body.

All instruments when used to measure radiant heat have in the same way some exposed part or sensitive surface, which is heated to such a temperature that it loses at the same rate that it absorbs heat; but in almost all cases there is this difference—instruments for measuring radiant heat do not, as a rule, give any indication of the actual temperature of the sensitive surface, but only of the excess of the temperature of this over that of the rest of the instrument, and thus these indications are equally valuable whatever the actual temperature may be.

When heat falls upon a thing and warms it, the rise of temperature produces a variety of physical effects, some of which are made use of to determine the rise of temperature, and therefore the rate at which heat falls upon the surface, while most are not conveniently available for this purpose. In the first place, whether the thing is a solid, or, if hollow, it contains a liquid or a gas, the rise of temperature in almost every case produces an expansion which may be made apparent by mechanical or electrical means.

If the thing that is warmed consists of a junction of two metals, an electromotive force is set up, producing a current the strength of which may be made a measure of the increase of temperature.

Or, again, if the thing that is warmed consists simply of a strip of conducting material, its electric resistance is altered—increased generally but decreased in the case of carbon—by a rise of temperature. Any change in the resistance of one part of a circuit through which a current is sent from an external source will alter the strength of the current, and if, by means of a differential galvanometer or Wheatstone's bridge, the effect of the current is balanced, then a change in the resistance will upset the balance, and this disturbance can be made evident by a galvanometer.

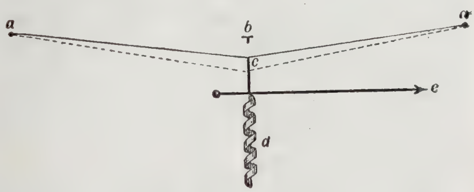
These three effects of heat—expansion, thermo-electromotive force, and change of resistance—are the only ones which are turned to account in instruments for measuring radiant heat.

Let us first consider the few instruments that exist, in which some material exposed to the radiant heat is expanded by the rise of temperature, and in which the change of volume gives rise to visible effects.

There are many ways of showing, with magnifying levers or other contrivance, that a rod of almost any material is lengthened by heat, but these are so insensitive that they would be quite unable to detect such feeble radiation as is easily measured in other ways. The expansion of a piece of brass wire, or even a glass rod, when slightly warmed, may be shown easily enough by allowing the end to roll over a fine needle, to which a straw is fastened as an index. Captain Cardew measures the rise of temperature in the wire in his voltmeter by magnifying the expansion with a wheel and pinion. The rise of temperature here, it is true, is not produced by radiation, but is the indirect result of the electromotive force to be measured; but I refer to it as it is one of the few practically useful instruments in which expansion produced by a rise of temperature in a solid is magnified and made evident by mechanical means.

Professors Ayrton and Perry magnify and measure the elongation due to the rise of temperature in the wire in their voltmeter by a very elegant device (Fig. 1). In the first

FIG. 1.



place, there is a fine wire stretched between two fixed points, *a a*, and pulled on one side by the action of a spring, *d*. When the wire is warmed, the spring pulls it a little further to one side, because it is longer, to a position shown by the dotted line. Now the additional distance to which the wire is pulled to one side is greater than the increase in length of either half of the wire, in the same proportion that *a c* is longer than *b c*; *i.e.*, it would be longer in this proportion if it were not for the fact that, as the angle at *c* diminishes, the power of the spring to stretch the wire diminishes also; nevertheless, the lateral motion at *e* is itself considerably greater than the expansion

of either half of the wire, and this increased motion is itself enormously magnified by the action of the spring itself. The spring is made with a twisted ribbon of the same shape as the shaving that is produced when a plane, held at an angle, takes a shaving off the edge of a plank. Such a spring (as Professors Ayrton and Perry have shown) twists through a large angle when it is pulled out, even through a small distance; therefore a balanced index on the end of the spring again magnifies the stretch of the wire, and thus a very feeble rise in temperature is made manifest.

I do not think that any one has suggested that these instruments might be used with advantage to measure radiation falling on the wire, nor do I think that any instrument depending on the expansion of a solid could compare in sensibility with those to be described.

The only instrument that I can remember that has been seriously put forward as a delicate means of measuring radiant heat, which does depend on the expansion which a rise in temperature produces in a solid body, is the tasimeter of Edison.

In this instrument the part of the apparatus exposed to radiation is a thin strip of vulcanite or of zinc, which is supported between a screw at one end and a carbon resistance at the other, so that when it expands by heat it shall increase the pressure on the carbon wafer, and so diminish its electrical resistance, an effect which can be easily and accurately observed by well-known electrical methods. There is a good account of this instrument in the *Telegraphic Journal* of November 15, 1878, by Professor Barrett, from which it is possible to get some idea of the sensibility of the tasimeter.

The following paragraph copied from the journal indicates what the instrument will do.

> "The heat radiated from one finger held near the cone is more than sufficient to drive the galvanometer index right across, and off the scale. In a letter relating to this tasimeter, Mr. Edison writes to me as follows:—'By holding a lighted cigar several feet away I have thrown the light right off the scale,' and by increasing the delicacy of the galvanometer 'the tasimeter may be made so sensitive that the heat from your body while standing 8 feet from and in a line with the cone, will throw the light off the scale, and the radiation from a gas jet 100 feet away gives a sensible deflection.'"

Professor Barrett went on to say that he considered the tasimeter to be a more sensitive instrument than the thermopile, as a thermo*scope*, but he did not think it would replace the thermopile, except possibly in investigation of the heat of spectra, owing to the linear form that can be given to the ebonite bar.

I have had no experience with this instrument, and, therefore, what I have to say is only an opinion based on experience of instruments of the highest degree of sensibility, and upon our general knowledge or rather ignorance of the behaviour of carbon resistances.

There seems to me to be one fatal defect in this instrument as an instrument of precision intended to be used in exact investigations. The indications of the instrument are perfectly arbitrary. We do not know the law according to which the resistance of these carbon wafers change with change of pressure. Though, as Professor Barrett says, as a thermoscope the instrument may be more sensitive than the ordinary thermopile, which at that time was the most delicate instrument in common use; though when nicely adjusted it might detect a minute change in the radiation falling upon it, the deflection of the galvanometer needle gave no measure of the amount of this change. But if the only fault was that the effect produced was not exactly proportional to the cause, a property common to many most useful instruments, this would be no great objection, for all that would have to be done would be to find out what deflections regulated additions of heat produced—it would be merely necessary to calibrate the instrument. But this I believe is impossible; I do not believe that if the instrument were set up and the calibration curves determined a dozen times, that any two of these curves would be the same. I simply state my belief; if I am wrong, I hope I may be corrected as speedily as possible. It is for this reason that I look upon this instrument simply as a -scope, and not a -meter.

Finally, among delicate means of observing the expansion of metal may be mentioned the well-known metallic thermometer of Breguet, which consists of three strips of metal—silver, gold, and platinum—soldered together face to face, and wound into a helix. During any change of temperature, the three metals change in length by different amounts, the platinum least and the silver most, and therefore the helix winds up or unwinds. This instrument, like the thermometer, essentially shows actual temperature, and not excess of temperature above surrounding bodies, a feature which does not belong to the voltmeters already mentioned, in which a change of temperature

in the whole instrument produces no effect, for all the parts are made to expand alike.

The expansion of a solid might be practically employed in an instrument for measuring radiant heat solely because the solid can be rolled or drawn into very thin strips or wires, which quickly take up the final temperature. The expansion of liquids in tubes cannot conveniently be employed for this purpose, because the amount of liquid that would be sufficient to produce a visible effect would be so great that the time occupied in coming to the final temperature would be enormous. It is only in such cases as that already referred to, where a thermometer *in vacuo* is used to measure the sun's radiation, the changes in which are comparatively slow, that a liquid can be used with any advantage to measure radiant heat.

If the capacity for heat of the bulb of the thermometer is known, and the rate at which it rises in temperature when exposed to the sun's rays, and the average falling in temperature when the sun's rays are screened from the instrument, then, knowing the area exposed by the bulb, we have at once the means of determining absolutely the rate at which heat is reaching the surface of the earth. This measurement is, however, more accurately made by a class of instruments devised for the purpose, of which one of the best known is the pyrheliometer of Pouillet. This consists of a thin box of metal with a flat base; the box is filled with water, and there is immersed in the water the bulb of a delicate thermometer, the stem of which passes down the tube of the instrument. At the lower end of this tube is fixed a disc the same size as the base of the box, so that the observer can, by casting the shadow of the box on this disc, place the bottom of the box square to the rays from the sun. As before, if the capacity for heat of the box, and the rate of heating in the sun, and the average rate of cooling when shaded are determined, we have at once a measure of the rate at which we receive heat from the sun.

Improvements in these instruments have been made by placing the bulb of a thermometer in a cavity maintained at a constant temperature, so that the rate of cooling may be more regular; but as my object in these lectures is to deal rather with instruments of a far more delicate order, I shall not say more on this part of the subject. But perhaps it may be worth while to give the figures that have been obtained for the sun's radiation. The quantity of heat which reaches the earth yearly would be sufficient to melt a layer of ice about 100 feet thick spread over the surface of the earth, and the quantity leaving the sun by radiation is sufficient to melt every hour about 2,000 feet of ice over the whole surface of the sun.

When we make use of the expansion of a gas, we at once have the means of observing far feebler effects than are possible with liquids and solids; in fact, it is possible to produce an instrument in which the expansion of a gas indirectly shows the presence of radiation which rivals any of the modern thermo-electric apparatus in delicacy, though not perhaps in ease of application.

The first advantages gained by the use of gas is the small weight and the great rate of expansion with rise of temperature. Air expands far more than alcohol; at ordinary temperatures it has a specific heat far less than that of alcohol, and its density is $\frac{1}{700}$ of the density of alcohol. Thus a given quantity of heat applied to a certain volume of air would produce an expansion for each of these reasons greater than it would do if applied to the same volume of alcohol; but as the capacity for heat of the containing bulb, in the case of air, is everything; while in the case of alcohol it is practically nothing, the differences are not quite so great as would at first appear. Still, in spite of the weight of the thin glass bulb, the rate at which the bulb of air is heated is enormous compared with that at which the same bulb of alcohol would be heated, and so it comes to its final temperature far more quickly than would any liquid, and then when it has done so, the expansion is far greater. The expansion of air at constant pressure is most easily found by using a special scale of temperature obtained by adding the figure 273 to the temperature, as measured by a centigrade thermometer, and calling this the absolute temperature, then the volume is proportioned to the absolute temperature, if the pressure is constant, or the pressure is proportional to the absolute temperature if the volume is constant. Thus if we make an air thermometer with a bulb two inches in diameter, and a tube one-tenth of an inch in diameter in the bore, the bulb has a capacity of 533 inches of the tube, and therefore the degrees will be very nearly two inches long. The air thermometer, consisting simply of a bulb and an open stem containing an index of some liquid is a very inconvenient instrument, because every change in the pressure as shown by a

barometer will produce its own effect; thus, if in the case taken the barometer were to fall one inch, from 30 to 29, the index would move more than 18 inches from this cause alone. For this reason, and also because in measuring radiant heat we want to observe the increase in temperature, and not the actual temperature, Leslie's differential air thermometer is more suitable. This simple instrument consists of a tube bent into the shape of a U with a bulb at each end, and with liquid filling half the tube. This instrument is rather less sensitive than the simple air thermometer, because in working it sets up a pressure due to the difference of level of the liquid in the two limbs which tends to compress the air where it is expanded, and to make it expand where it is contracted; further, the bulb not exposed to the radiation has the air in it compressed by the expansion of the air in the warmer bulb. The first of these opposing causes is removed in Rumford's differential thermometer, in which the horizontal limb of the U is very long, and the vertical legs short. The short index of liquid in moving along the horizontal tube does not set up any opposing hydrostatic pressure. With the first of these instruments Leslie made his researches on radiant heat before the thermopile had been invented, and as is so often the case with the true experimentalist, he thus made his most famous discoveries with the simplest possible means.

A modification of the differential thermometer has been devised by Prof. H. F. Weber, of Zurich, of which a very short account is given in the "Archives de Genève," 1887, p. 347; so short, in fact, that it is impossible to criticise the instrument until more details have been published.

In this instrument, which Professor Weber calls a microradiometer, the two bulbs of a differential thermometer are replaced by two thin boxes of brass, one end of each of which is made of a plate of rock salt. These boxes are joined to the two ends of a glass tube with a bore about 1 square mm. in area, which has a small bulb blown near each end. The middle of this tube is filled with mercury, and the bulb and about 5 mm. of the tube at each end is filled with a solution of sulphate of zinc, which is prevented by capillarity from escaping into the boxes. If one box is warmed more than the other, then, as in the ordinary differential thermometer, the liquid in the tube is driven a small way towards the other bulb. The peculiarity of the instrument depends on the way in which this motion is made evident. The 5 mm. or so of sulphate of zinc solution between the bulbs, and the mercury in the tube at each end, form two of the arms of a Wheatstone's bridge; the other two arms consist of a pair of resistances as usual, which are put into electrical connection with the sulphate of zinc solution by wires sealed into the bulb. When, owing to the warmth of one of the boxes, the column of sulphate of zinc is lengthened in one end of the tube and is shortened in the other end, the resistance of the one end is increased and that of the other diminished, and thus there is a double disturbance of the balance of the bridge, which at once makes itself felt in the galvanometer.

With this complex apparatus Professor Weber says he can detect a one-hundred millionth of a degree, and that the heat of the moon produces an oscillation of about a hundred divisions of the scale.

I can only conclude, from the very short account at present published, that this instrument is very sensitive, far more sensitive than anyone would expect; but whether the indications given by the instrument bear any direct relation to the increase of temperature of the boxes, there is at present no evidence to show. The inventor gives as the theory of the instrument that it is a simple Wheatstone bridge, and that the change of resistance of the arms is the cause of the want of balance. I am inclined to think that this must be very much involved with another action that must certainly come into play. When one of the boxes is warmed, the liquid is driven from that side, but if the increase of temperature—and therefore the acting pressure—is very small, the liquid will not simply move along and take a new position; the ends of the column of mercury will certainly move irregularly, and will also change in shape to a slight extent. Owing to the change of shape electro-capillary action will be set up—that is, an electromotive force will be set up independently of that due to the battery, which will affect the galvanometer if the bridge connections are so made that the galvanometer is connected with the two bulbs; whereas it should produce no effect—or but a slight effect—on the deflection if the galvanometer connects the mercury thread and the two resistances. Which arrangement is made, the paper does not show. It is very difficult to believe that each hundred millionth of a degree by which one box is warmed will produce the proper motion of the liquid due to it. The pressure that this temperature represents is about one thirty thousand

millionth of an atmosphere; that is a pressure of one thousand millionth of an inch of mercury, or a pressure of about one hundred millionth of an inch of water. The experience of most physicists is, that in a capillary tube with four separate capillary surfaces, such a pressure would not cause any real movement of the liquid as a whole. It is easy to understand that in the case of larger differences of temperature the effect produced will be so enormous that, if all went in proportion, the one-hundred millionth of a degree could be detected; just as in the ordinary wheel barometer—in which the motion of the mercury is greatly magnified—the index would be capable of showing, if all went in proportion, thousandths or perhaps ten-thousandths of an inch, whereas every one knows that in this case you can, by judicious tapping, make the index rest in a variety of positions. I do not wish to be understood to say that this is the case with Weber's instrument, but only that this is what any one would expect. It is to be hoped, therefore, that we shall have details before long which will set these doubts at rest.

The air thermometer referred to so far may be classed among statical instruments. They come to rest when a certain definite change of temperature has been produced, and the position of the index is a measure of that change or difference of temperature.

There is another way in which the expansion of a gas may serve to indicate change of temperature. When a gas—air, for instance—is warmed, and therefore caused to occupy a larger space, the density of the gas of course becomes less. The gas, being lighter, rises, and produces the well-known rising current of hot air to which I drew your attention at the beginning of this lecture. These air currents are only too well known to the experimentalist. If, in weighing anything—a crucible, say—the thing being weighed is not quite cold, it warms the air round it, and sets up a current of air which altogether disturbs the balance, and makes the thing seem too light. If the sun shines upon one end of the balance case it warms it, and sets up air currents which again disturb the equilibrium. A gas burner near the balance will do the same thing. Cavendish found, in that famous experiment by means of which he found the mass of the earth, *i.e.*, the number of tons of material which go to make the earth, that a difference of temperature produced by definite means, but still probably too small to be shown with a thermometer, produced disturbances which altogether masked the effect which he was measuring, and these disturbances were simply caused by air currents. The Rev. A. Bennet, F.R.S., in a paper of very great interest, and which is very refreshing in these days of centimetres, grammes, and seconds ("R. Soc Trans.," 1792), shows how air currents set up in this way may be used to detect the most extraordinarily feeble radiation. I give his own account of his fifth experiment.

"Several other light substances were suspended by fine spider threads and placed in a cylindrical glass about two inches in diameter, as the thinnest part of the wing of a dragon-fly, thistle-down, and the down of dandelion; of these, the last appeared most sensible to the influence of heat, for when the down was fastened to one end of a fine gold wire it would turn towards any person who approached at the distance of three feet, and would move so rapidly towards wires only heated by my hand, as very much to resemble magnetic attraction."

Again, Mr. Crookes in some of his researches, when great accuracy was required, was obliged to place his balance in a vacuum, and then, curiously enough, other irregularities were observed which led him to examine in greater detail what happened when radiation fell on light suspended bodies. He found, as had been found before, that these things appeared to be attracted by the influence of radiation. They were really warmed, and the current produced caused the appearance of attraction. On trying the same experiment under diminished pressures, this apparent attraction after a time ceased, and then when the vacuum was sufficient, repulsion was observed instead. In this way he was led to the invention of that marvellous instrument, the radiometer, and afterwards to the discovery of those extraordinary effects due to what he called radiant matter. I do not know whether I ought not to include the radiometer and several other of Mr. Crookes's pieces of apparatus in the catalogue of instruments for measuring radiant heat. They certainly do measure in a way; in fact, in one of his tubes Mr. Crookes arranged a torsion balance, by means of which he actually weighed the repulsion due to a certain beam of light. The subject of his instrument is itself so vast that I really dare not enter upon it, and I think I am justified, for radiometers do not, as far as I know, supply convenient means of making accurate comparisons of feeble degrees of radiation.

There is no end of the number of instances

that might be given of the effect of air-currents produced by even feeble degrees of radiation. Every experimentalist must have met with many instances. Though the effects are so strongly marked, I do not think much has been done to make use of these currents to measure radiation. There are the experiments of Mr. Bennet and Mr. Crookes, already referred to; there is also an instrument devised by Joule, and described in the first volume of his papers published by the Physical Society, p. 535, which I cannot do better than describe in his own words:—

"A glass vessel in the shape of a tube, 2 feet long and 4 inches in diameter, was divided longitudinally by a blackened pasteboard diaphragm, leaving spaces at the top and bottom each a little over 1 inch. In the top space, a bit of magnetised sewing-needle, furnished with a glass index, is suspended by a single filament of silk. It is evident that the arrangement is similar to that of a 'bratticed' coal-pit shaft, and the slightest excess of temperature on one side over that on the other must occasion a circulation of air, which will ascend on the heated side, and after passing the fine glass index, descend on the other side. It is also evident that the sensibility of the instrument may be increased to any required extent, by diminishing the directive force of the magnetic needle." *

I have made and now show an instrument of this class, in which the vane consists of a fragment of straw suspended by a quartz fibre one ten-thousandth of an inch in diameter. The arrangement is so delicate that it is in this form quite unusable, but it would seem, as it did to Joule, to be capable of being developed into a serviceable instrument.

Both Joule and Weber make use of the moon, to show the extreme sensibility of their instrument. It was long a question whether any heat was sent to the earth from the moon. Prof. Tyndall, in speaking of this heat, says:—"Concentrated by a polyzonal lens more than a yard in diameter upon the face of his pile, it required all Melloni's acuteness to *nurse* the calorific action of the moon up to a measurable quantity." I shall return to the moon's heat in another lecture, and show that this is not really a fair comparison; but it is, I hope, sufficiently evident that, by means of the air current itself, it is possible to detect effects of heat so feeble in amount that nothing but the most delicate apparatus would be thought capable of making their existence evident.

* "Proc. Manchester Lit. and Phil. Soc." Vol. iii., p. 73.

Miscellaneous.

*THE ORIGIN OF PETROLEUM.**

The enormous consumption of petroleum and natural gas frequently raises the question as to the probability of the proximate exhaustion of the supply; and, without doubt, many fear to adopt the use of oil, from a feeling that if such use once becomes general, the demand will exceed the production, the price will rise indefinitely, and old methods of illumination, and old forms of fuel, will have to be reverted to. From this point of view it is most interesting to inquire what are the probabilities of a continuous supply; and such an investigation leads at once to the question, "What is the origin of petroleum?" In the year 1877, Professor Mendeleeff undertook to answer this question; and as his theory appears to be very little known, and has never been fully set forth in the English language, I trust you will forgive me for laying a matter so interesting before you. Dr. Mendeleeff commences his essay by the statement that most persons assume, without any special reason—excepting, perhaps, its chemical composition—that naphtha, like coal, has a vegetable origin. He combats this hypothesis, and points out, in the first place, that naphtha must have been formed in the depths of the earth. It could not have been produced on the surface, because it would have evaporated; nor over a sea bottom, because it would have floated up and been dissipated by the same means. In the next place he shows that naphtha must have been formed beneath the very site on which it is found—that it could not have come from a distance, like so many other geological deposits, and for the reasons given above, namely, that it could not be water-borne, and could not have flowed along the surface, while in the superficial sands in which it is generally found no one has ever discovered the presence of organised matter in sufficiently large masses to have served as a source for the enormous quantity of oil and gas yielded in some districts; and hence it is most probable that it has risen from much greater depths under the influence of its own gaseous pressure, or floated up upon the surface of water, with which it is so frequently associated.

The oil-bearing strata in Europe belong chiefly to the Tertiary or later geological epochs; so that it is conceivable that in these strata, or in those immediately below them, carboniferous deposits may exist, and may be the sources of the oil; but in America and in Canada the oil-bearing sands are found in the Devonian and Silurian formations, which are either destitute of organic remains, or

* Extracted from Mr. Anderson's Presidential Address to Section G (Mechanical Science) of the British Association.

contain them in insignificant quantities. Yet if the immense masses of hydrocarbons have been produced by chemical changes in carboniferous beds, equally large masses of solid carboniferous remains must still exist; but of this there is absolutely no evidence, while cases occur in Pennsylvania where oil is obtained from the Devonian rocks underlying compact clay beds, on which rest coal-bearing strata. Had the oil been derived from the coal it certainly would not have made its way downwards; much less would it have penetrated an impermeable stratum of clay. The conclusion arrived at is, that it is impossible to ascribe the formation of naphtha to chemical changes produced by heat and pressure in ancient organised remains.

One of the first indices to the solution of the question lies in the situation of the oil-bearing regions. They always occur in the neighbourhood of, and run parallel to, mountain ranges—as, for example, in Pennsylvania, along the Alleghanies; in Russia, along the Caucasus. The crests of the ranges, formed originally of horizontal strata which had been forced up by internal pressure, must have been cracked and dislocated, the fissures widening outwards, while similar cracks must have been formed at the bases of the ranges; but the fissures would widen downwards, and would form channels and cavities into which naphtha, formed in the depths to which the fissures descended, would rise and manifest itself, especially in localities where the surface had been sufficiently lowered by denudation or otherwise.

It is in the lowest depths of these fissures that we must seek the laboratories in which the oil is formed and once produced it must inevitably rise to the surface, whether forced up by its own pent-up gases or vapours, or floated up by associated water. In some instances the oil penetrating or soaking through the surface layers loses its more volatile constituents by evaporation, and, in consequence, deposits of pitch, of carboniferous shales, and asphalte take place; in other cases, the oil, impregnating sands at a lower level, is often found under great pressure, and associated with forms of itself in a permanently gaseous state. This oil may be distributed widely according to the nature of the formations or the disturbances to which they have been subjected; but the presence of petroleum is not in any way connected with the geological age of the oil-bearing strata; it is simply the result of physical condition and of surface structure.

According to the views of Laplace, the planetary system has been formed from incandescent matter torn from the solar equatorial regions. In the first instance this matter formed a ring analogous to those which we now see surrounding Saturn, and consisted of all kinds of substances at a high temperature, and from this mass a sphere of vapours, of larger diameter than the earth now has, was gradually separated. The various vapours and gases which, diffused through each other, formed at first an atmosphere round an imaginary centre, gradually assumed the form of a liquid globe, and exerted pressures incomparably higher than those which we experience now at the base of our present atmosphere. According to Dalton's laws, gases, when diffused through each other, behave as if they were separate; hence the lighter gases would preponderate in the outer regions of the vaporous globe, while the heavier ones would accumulate to a larger extent at the central portion, and at the same time the gases circulating from the centre to the circumference would expand, perform work, would cool in consequence, and at some period would assume the liquid or even the solid state, just as we find the vapour of water diffused through our present atmosphere does now. That which is true of changes of physical condition, Henri St. Claire Deville, in his brilliant theory of dissociation, has shown to be equally true with respect to chemical changes; and the cooling of the vapours forming the earth while in its gaseous condition was necessarily accompanied by chemical combinations, which took place chiefly on the outer surface, where oxides of the metals were formed; and as these are generally less volatile than the metals themselves, they were precipitated on to what there then was of liquid or solid of the earth, in the form of metallic rain or snow, and were again probably decomposed, in part at least, to their vaporous condition. The necessary consequence of this action is that the inner regions of the earth must consist of substances the vapours of which have high specific densities and high molecular weights—that is to say, composed of elements having high atomic weights—and that the heavier elementary substances would collect near the centre, while the lighter ones would be found nearer the surface. Our knowledge of the earth's crust extends but to an insignificant distance; yet, as far as we do know it, we find that the arrangement above indicated prevails. Hydrogen, carbon, nitrogen, oxygen, sodium, magnesium, aluminium, silicon, phosphorus, sulphur, chlorine, potassium, calcium, substances whose atomic weights range from 1 to 40, became condensed, entered into every conceivable combination with each other, and produced substances the specific gravity of which averages about $2\frac{1}{2}$, never exceeds 4, and are found near the immediate surface of the globe.

But the mean specific gravity of the earth as determined by Maskelyne, Cavendish and others certainly exceeds 5, and consequently the inner portion of our globe must be composed of substances heavier than those existing on the surface, and such substances are only to be found among the elements with high atomic weights. The question arises, what elements of this character are we likely to find in the depths of the earth? In the first place, since gases diffuse through each other, a certain proportion of the elements of high atomic weight will also be found on the surface of the earth. Secondly, the elements forming the bulk of the earth must be found in the atmosphere of the sun—

if, indeed, the earth once formed part of its atmosphere; and of all the elements, iron, with a specific gravity exceeding 7, and with an atomic weight of 56, corresponds best with these requirements, for it is found in abundance on the surface of the earth; and the spectroscope has revealed the very marked presence of iron in the sun, where it must be partly in the fluid and partly in the gaseous state; and, consequently iron in large masses must exist in the earth; so that the mean specific gravity of our planet may well be 5, the value of which has been determined by independent means.

It is not easy, however, to define in what condition the mass of iron which exist in the heart of the earth is likely to be. Iron is capable of forming a vast number of combinations, depending on the relative proportion of the various elements present. Thus, in the blast-furnace, oxygen, carbon, nitrogen, calcium, silicon, and iron are associated, and produce, under the action of heat, besides various gases, a carburet of iron and slag, the latter containing chiefly silicon, calcium, and oxygen—that is to say, substances similar to those which form the bulk of the surface of the earth. But these same elements, if there be an excess of oxygen, will not yield any carburet of iron: and the same result will follow if there be a deficiency of silicon and calcium, because of the large proportion of oxygen which they appropriate. In the same way, during the cooling of the earth, if oxygen, carbon, and iron were associated, and if the carbon were in excess of the oxygen, the greater part of the carbon would escape in the gaseous state, while the remaining part would unite with the iron. It is certain that, in the heart of the earth, there must have been a deficiency of oxygen, because of its low specific gravity; and the argument is supported by the fact that free oxygen and its compounds, with the lighter elements, abound on the surface. Further, it must be presumed that much of the iron existing at great depths must be covered over and protected from oxygen by a coating of slag; so that, taking all these considerations into account, it is reasonable to conclude that deep down in the earth there exist large masses of iron, in part at least in the metallic state, or combined with carbon.

The above views receive considerable confirmation from the composition of meteoric matter, for it also forms a portion of the solar system, and originated, like the earth, from out of the solar atmosphere. Meteorites are most probably fragments of planets, and a large proportion of them include iron in their composition, often as carbides, in the same form as ordinary cast-iron—that is to say, a part of the carbon is free, and a part is in chemical union with the iron. It has been shown, besides, that all basalts contain iron, and basalts are nothing more than lavas forced by volcanic eruptions from the heart of the earth to ts surface. The same causes may have led to the existence of combinations of carbon with other metals.

The process of the formation of petroleum seems to be the following:—It is generally admitted that the crust of the earth is very thin in comparison with the diameter of the latter, and that this crust encloses soft or fluid substances, among which the carbides or iron and of other metals find a place. When, in consequence of cooling or some other cause, a fissure takes place through which a mountain range is protruded, the crust of the earth is bent, and at the foot of the hills fissures are formed; or, at any rate, the continuity of the rocky layers is disturbed, and they are rendered more or less porous, so that surface waters are able to make their way deep into the bowels of the earth, and to reach occasionally the heated deposits of metallic carbides, which may exist either in a separated condition or blended with other matter. Under such circumstances it is easy to see what must take places. Iron, or whatever other metal may be present, forms an oxide with the oxygen of the water; hydrogen is either set free or combined with the carbon which was associated with the metal, and becomes a volatile substance—that is, naphtha. The water which had penetrated down to the incandescent mass was changed into steam, a portion of which found its way through the porous substances with which the fissures were filled, and carried with it the vapours of the newly formed hydrocarbons, and this mixture of vapours was condensed wholly or in part as soon as it reached the cooler strata. The chemical composition of the hydrocarbons produced will depend upon the conditions of temperature and pressure under which they are formed. It is obvious that these may vary between very wide limits, and hence it is that mineral oils, mineral pitch, ozokerit, and similar products differ so greatly from each other in the relative proportions of hydrogen and carbon. I may mention that artificial petroleum has been frequently prepared by a process analogous to that described above.

Such is the theory of the distinguished philosopher, who has framed it not alone upon his wide chemical knowledge, but also upon the practical experience derived from visiting officially the principal oil-producing districts of Europe and America, from discussing the subject with able men deeply interested in the oil industry, and of collecting all the available literature on the subject. It is needless to remark that Dr. Mendeleeff's views are not shared by every competent authority; nevertheless the remarkable permanence of oil-wells, the apparently inexhaustible evolution of hydrocarbon gases in certain regions, almost forces one to believe that the hydrocarbon products must be forming as fast as they are consumed, that there is little danger of the demand ever exceeding the supply, and that there is every prospect of oil being found in almost every portion of the surface of the earth, especially in the vicinity of great geological disturbances. Improved methods of boring wells will enable greater depths to be reached; and it should be remembered that, apart from the cost of sinking a deep well, there is no extra expense in working at great depths, be-

cause the oil generally rises to the surface or near it. The extraordinary pressures, amounting to 300 lbs. per square inch, which have been measured in some wells seem to me to yield conclusive evidence of the impermeability of the strata from under which the oil has been forced up, and tend to confirm the view that it must have been formed in regions far below any which could have contained organic remains.

CHINESE PRIZE ESSAY SCHEME.

The second report of the Chinese Prize Essay Scheme, in connection with the Chinese Polytechnic Institution and Reading-rooms, Shanghai, has been printed, and the following particulars are extracted from it:—

Since the last report, which was published in 1887, the scheme has been steadily worked, and has now expanded into far more extensive proportions. By its means the existence of the Polytechnic Institution has become known far and wide; the co-operation of some of the highest officials in the empire secured; and an interest in western ideas has been created in some of the most influential quarters. By the annual expenditure of only a hundred taels or thereabouts, and by working in harmony with the Chinese methods of thought, and time-honoured systems of literary competition, a result has been obtained which the use of large sums of money in other ways would have failed to produce.

The various other officials who have taken part in this undertaking have generally shown a wonderful insight into the needs of China at the present time; and although their questions relate, perhaps, more to political economy and commerce than to the severer branches of science, it is still gratifying to see how patriotic they are, and how they regard knowledge from the practical, utilitarian point of view, rather than from the theoretical alone.

The following questions are taken from the list of subjects given by the various high officials:—

"Write a discourse on the naval defences of China."

"What ought China at the present time to regard as of the foremost importance in her endeavours to improve in wealth and power?"

"What advantages and disadvantages would China realise by the establishment of railways?"

"Compare the sciences of China and the West, showing their points of difference and similarity."

"How can the evils attending the introduction of telegraphs and steamboats in China be removed, and the benefits be rendered permanent?"

"What is the cause of the present unprofitable state of the trade in tea and silk, and how can the difficulties be remedied?"

"The calamities of inundations and droughts, how can they be provided against in ordinary times; and when they happen how can they be remedied or ameliorated?"

TOBACCO IN PARAGUAY.

Tobacco is one of the principal products of Paraguay, and is cultivated in all sections, though that grown at Luque, Itagna Ita, and Villa Rica is most highly prized. In 1886 the amount of tobacco exported rose to 406,006 arrobes, valued at £164,000. In addition, large quantities are consumed at home. It has been stated that the annual average consumption is from ten to fifteen pounds per head, for smoking is universal, and indulged in alike by men, women, and children. It is not uncommon, says Consul Hill, of Asuncion, to see children just able to walk with cigars in their mouths. *Peti-hoby*, the original kind cultivated in the reign of Francia, is blue, mostly grown at Villa Rica, and kept for home use; *Peti-para*, more recently introduced from Cuba, is yellow, and is chiefly sold for exportation. Analysis has shown that the former contains 3 per cent., and the latter 6 per cent. of nicotine. A species o Havana tobacco is grown at Luque and Villa Rica, cigars made from it having, it is said, a flavour equal to the best Bahia brands. The plants are put down in September and transplanted in November; the gathering begins in January, and the leaves are hung out to dry until the *acopiador* comes into the district to buy. At the Paris Exhibition in 1855 a gold medal was awarded for samples of *Peti-hoby* and *Peti-para*. The industry has increased greatly of late years, for in 1829 the crop amounted to only 2,675,000 lbs., rising in 1860 to 15,000,000lbs. Tobacco growing is very profitable, and is said to return 50 per cent. on the capital invested. The Argentine Republic and Uruguay have hitherto been the chief markets for this article of export, but they have recently taken to its cultivation themselves, and have placed a heavy duty on that imported, so it is desirable that Paraguay should find a European market for their product. A Dutch company has recently begun the growing of tobacco on a laage scale at Lambaré, near Asuncion. They have secured certain privileges from the Government, among them exemption from duties.

Correspondence.

MR. ALAN S. COLE'S CANTOR LECTURES ON "EGYPTIAN TAPESTRY."

Mr. Alan Cole's two Cantor Lectures on the collection of old Coptic fabrics from Akhmîm [Chemmis Panopolis], recently purchased by the Science and Art Department for the South Kensington Museum, are the most important and valuable that have ever, within my memory, been delivered, on an antiquarian art

subject, before our Society. The Society is honoured by having them recorded in its *Journal*. Nothing could be simpler or more informing than the manner in which the lecturer has focussed on them the whole history of the time covered by these fabrics, thus enabling us to appreciate in the clearest light the various intricate influences that fostered their production; and nothing more admirable and suggestive than his analysis of the comparative history of their ornamental motives and designs. These Akhmîm fabrics have proved a perfect revelation to the student of the history of artistic types, and supplemented as they are by the contemporary paintings of the Catacombs at Rome, and of the Caves at Ajanta, leave little to be desired in the elucidation of the history of decorative art through the transition period, from the breaking up of antiquity, with the fall of the Roman and Persian (Sassanian) empires, to the consolidation of the modern world, with the rise of the states of Christendom and Islam. It is scarcely creditable to the enterprise or intelligence of our leading publishing firms, that not one of them should have yet provided English readers with a fully illustrated work on these fabrics by such a master of the subject as Mr. Alan Cole has shown himself to be; and I would fain hope that the deep interest of Mr. Cole's recent lectures may lead to their being reproduced in a separate and standard form for general reference. In connection with these fabrics, there is a passage in Vansleb's "Present State of Egypt, 1672-3," which Mr. Cole may like to have for any future edition of his lectures. It is to be found at page 10, and is as follows:—"The Copties at present in Egypt are not numerous, in comparison with what they have been heretofore; for in the days of Amru ibu il Ass (*i.e.*, 'Amr ibn al-'Asi), who took this country from the Greeks, there was of this nation 600,000 that paid him tribute: but now, according to the relation of their own Patriarch, there is scarce 10,000 or 15,000. One of the causes of this decrease, was their constancy to the Christian religion in the time of the Romans. Their governors were so furious against them for that reason that they have put to death millions at a time; for the histories tell us of the governor under Diocletian, the emperor, who massacred in one night, at Christmas, four score thousand, who are buried upon Mount Achmim, in Upper Egypt. And at another time, near Isna (Esne, Latopolis), either the same governor, or another, put to death so many that they were not to be numbered, for they covered fourscore fiddans, or furlongs, with their dead martyr'd bodies." This is a very remarkable passage, and the Science and Art Department, or the British Museum, might do worse than undertake to examine Esne in search of another vast find of these wonderful fabrics. It is obvious that all those found at Akhmîm belong to the Roman period. The ancient Egyptians were forbidden to enter a temple or to be buried in woollen stuffs; and after the Arab conquest of Egypt, the Copts, while spared from massacre for having, in revenge against the "Malikites" of Constantinople, betrayed Egypt to the Mahomedans, were compelled, in token of subjection to their new masters, to adopt the plain and sober-coloured black, brown, grey, and blue, and predominantly blue vestments, by which they are distinguished at the present day.

With reference to the marked reversion throughout the Roman world under the Empire of the industrial arts from their rationalised Greek type to their original Asiatic type, we must never forget that this was due not only to the indirect influence of the revival of the prosperity of the East under the peace secured to it by the Cæsars, but was, in a still greater measure, directly brought about by the practice of the Romans, during the Empire, of employing the prisoners taken by them in their Asiatic wars not only as servants and field labourers, but as artisans. In this way, not only the whole agriculture of Italy, but the practice of all the industrial arts of the country gradually passed out of the hands of the native population into those of Asiatic slaves, from whom the inventive and gradually progressive Hellenised handicrafts of Europe received that strongly renewed, stererеotyped Oriental stamp, characteristic of them thenceforward to the end of the Middle Ages, and still impressed on the ecclesiastical art of the West. Christianity itself, indeed, in doctrine, ritual, discipline, and all but its later Roman organisation, was part and parcel of the reversion of European culture at this time from its Hellenic to a revived Asiatic type; for this reversionary movement became universal, affecting science, philosophy, religion, and art, as well as the merely technical arts.

GEORGE BIRDWOOD.

September 14, 1889.

General Notes.

DRIED FRUIT.—According to the last report of the Commissioners of her Majesty's Customs the revenue from dried fruit has again made a further advance, the increase in the receipt over that for 1887-88 being £43,655, or 7·5 per cent. Against an increase from currants of £36,283, or 11·1 per cent., and from figs, plums, and prunes of £7,372, or 16·4 per cent., must be placed a decrease from raisins of £3,081, or 1·7 per cent. The crop of currants was exceptionally large in 1888, and the improved vintage in France led to a smaller demand for dried currants by the wine manufacturers in that country, who, during the period of the ravages of the phylloxera had had recourse to the aid of currants from Greece in the preparation of their wines.

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FRIDAY, SEPTEMBER 27, 1889.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

EXAMINATIONS, 1890.

The subjects of examination are—1. Arithmetic; 2. English (including composition and correspondence, and précis writing); 3. Book-keeping; 4. Commercial Geography; 5. Shorthand; 6. French; 7. German; 8. Italian; 9. Spanish; 10. Portuguese; 11. Russian; 12. Danish; 13. Chinese; 14. Japanese; 15. Political Economy; 16. Domestic Economy; 17. Theory of Music; 18. Practice of Music; 19. Practical Commercial Knowledge.

These examinations will be held on April 14, 15, 16, and 17, with the exception of that in the Practice of Music, which will be held during the week commencing on the 2nd of June.

The Programme is now ready, and copies can be obtained gratis on application to the Secretary.

Proceedings of the Society.

CANTOR LECTURES.

INSTRUMENTS FOR MEASURING RADIANT HEAT.

By C. V. Boys, A.R.S.M., F.R.S.

Lecture II.—Delivered April 1st, 1889.

In the last lecture I dealt with the subject of instruments which show the effect of heat by the expansion of something, whether a solid, a liquid or a gas, and showed that while in general these instruments are not capable of showing very feeble effects, yet three of them —Edison's tasimeter, Weber's microradiometer, and Joule's convection thermometer—are, according to all accounts, much more sensitive to the influence of radiant heat than we should be led to expect if we consider the very small co-efficient of expansion of bodies for heat. In two of these instruments a change of electrical resistance is the indirect result of the increased temperature of the part of the apparatus exposed to radiation, and in these cases the sensibility simply depends upon the sensibility of the galvanometer that is used in conjunction with the apparatus.

The second class of instruments to which I referred in the last lecture, instruments depending on thermo-electromotive force, are of two kinds, those in which there is a fixed thermo-pile or thermo-junction, which sends a current when it is warmed round the needles of a galvanometer, the deflection of which is a measure of the heat poured into the instrument; and, secondly, those in which the thermo-electric circuit is suspended in a strong magnetic field, in which it tends to turn round when a current is sent round the circuit in consequence of the heating of the junction.

The third class of instruments to which I referred are those in which heat changes the electrical resistance of a conductor which is exposed to the radiation, and in which the change of resistance is observed—as in the case of the tasimeter—by means of a galvanometer, either arranged differentially or with a Wheatstone's bridge, so as to obtain the greatest delicacy possible.

All these instruments for measuring radiant heat, which are of an electrical character, require the aid of a galvanometer, or in a few instances they act as their own galvanometer; but in every case they require that a suspending fibre of some kind shall be used, since no pivots that can be made are so devoid of friction as not to completely destroy all chance of observing those minute effects which are within the grasp of the experimentalist.

Since this subject of suspending fibres is of the first importance in nearly all instruments of precision, not only in those which form the subject of these lectures, and since the fibres that are at present in common use all are subject to defects of a very serious character, I feel that I shall not be giving too much time to this part of the subject if I devote the whole of this lecture to its consideration, more espe-

cially as I shall be able to show that the annoyance to which the physicist is constantly exposed, owing to the vagaries of his silk suspensions, is no longer a necessity, and that the limit of accuracy which in many cases is due to the same cause, no longer is determined by the uncertainty of the suspending fibre, but by other causes which, in the presence of silk, are of no account. I shall, therefore, treat this subject of suspension on rather broader lines than I would do if I were merely considering galvanometer construction.

Of all the means that we possess of measuring minute forces, the torsion of a wire or thread is more convenient than any other, because no matter whether the force to be measured is a mere pull, as in the case of an attraction, or a twist, as in the case of a magnetometer or electrometer needle, torsion may be used, as in the first case, the pull may be applied to the end of an arm carried by the torsion thread, and in the second the turning force or moment may be applied direct.

By means of the torsion of an ordinary piece of brass or German silver wire, a foot long, and as much as 1-50th of an inch in diameter, forces as little as the weight of a single grain can be made evident to an audience. For instance, I have a straw suspended from such a wire, on the end of which I have placed a fragment of sheet iron weighing 10 grains. A weak magnet is incapable of lifting the piece of iron, yet it is able to pull it round through a large angle, and therefore to twist the wire to the same extent. One-tenth of this movement of this straw would be visible to everyone in the room, and, therefore, a force as small as the weight of a single grain, a force which, to our senses is inappreciable, can be made evident with wire as thick as this. If, instead of a plain straw turning round over the table we had a fine index passing over a scale, or, better, a mirror reflecting a beam of light on to a scale, then it would be possible, with the same wire to observe the effect of a force a hundred or a thousand times less.

With a finer wire, as is evident, feebler forces may be measured, but it is not at once evident to what extent a fine wire, say one half the diameter, will be more sensitive.

If the wire has half the diameter it will be sixteen times as sensitive, because $2 \times 2 = 4$, $4 \times 4 = 16$; and so for any other number. The torsion varies as the fourth power of the diameter.

Now going back to the experiment in which it was shown that with a wire one-fiftieth of an inch thick the torsion was sufficiently small to make it possible to measure forces which to our senses are quite unobservable, forces of one-hundredth or one-thousandth the weight of a grain, it is evident what an enormously-increased delicacy would be obtained by using a wire, say, of one-tenth the diameter—and still finer wire than this can be obtained in any quantity. In this case, since $10 \times 10 = 100$, and $100 \times 100 = 10{,}000$, the force that would be required to produce a given twist in the thinner wire would be 10,000 times less than is necessary in the thick wire; therefore forces as small as one millionth or one ten-millionth of the weight of a grain would with this simple apparatus be observable.

It was with apparatus such as this, devised in the first instance by Mitchell, an English clergyman, that Coulomb made his famous researches upon the forces between electrified or magnetised bodies, and that Cavendish determined the mass of the earth.

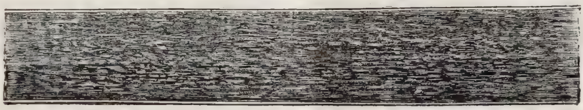
The torsion of such a wire is so small that it might seem at first as if nothing finer could be required; but as a matter of fact, if the needles of an ordinary reflecting galvanometer were suspended by such wire, they would be held so immovably as to make them incapable of responding to such currents as are now easily measured. The forces and moments about which I have been speaking, though they seem very small indeed, are in reality enormous compared with those which can be easily measured. If still finer torsion threads are required a difficulty is met with. When wire is made much less than one five-hundredth of an inch, it begins to suffer in the process of drawing. Copper wire is now made almost one thousandth of an inch in diameter, but this wire is very weak, and difficult to use. I have a specimen of silver wire of this size, given me by Mr. Lecky, which shows well the way in which the surface has been damaged in the process of drawing. As there is a difficulty in showing these fine wires and threads to a number by means of the projection microscope, I have asked Mr. Chapman to photograph for me, with a microscope, the series of wires and threads of which I have to speak to-night, all on the same scale. Photographs perfectly show the appearance that these things present under the microscope, and at the same time they serve most excellently to show the actual size of the several fibres. In the first place, there is a photograph of

micrometer (Fig. 2).* Each division is one thousandth of an inch. I have made corres-

FIG. 2.

ponding marks on the screen, which will serve as reference marks when other slides are projected upon it. By way of giving some idea of the dimensions, I would point out that this wire to which I have so often referred would, on the scale on which the photographs are taken, completely cover the screen; it would appear about 25 feet wide. The next slide (Fig. 3) is an ordinary human hair, which I show because people speak of a hair as though

FIG. 3.



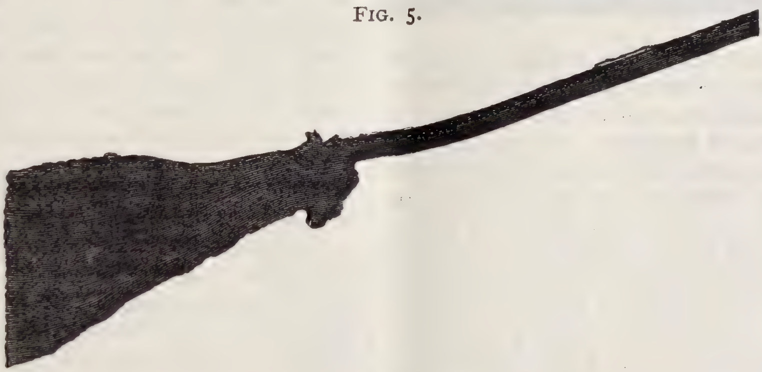
it were very fine. The next slide (Fig. 4) is a piece of copper wire, about one-thousandth of an inch in diameter.

FIG. 4.

Very fine wire is made by Wollaston's process of enveloping a platinum wire in silver, and then drawing the compound rod into fine wire, after which the silver is dissolved by nitric acid. There is then left an exceedingly fine wire of platinum which, however, is, I believe, useless as a torsion fibre. The photograph on the screen (Fig. 5) is taken from a specimen from which the silver had been dissolved only up to a certain place. The end of the silver and the platinum core are evident. This is a two-thousandth of an inch in diameter; it is about the same size as a split cocoon fibre.

There is a beautiful material to which I imagine many experimentalists must have turned in their endeavour to find a fine

FIG. 5.



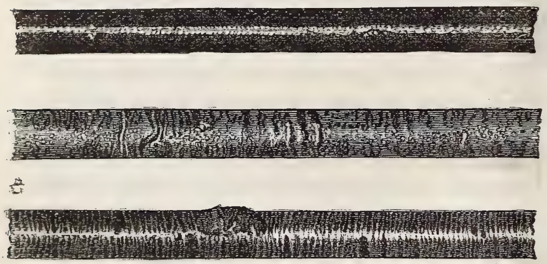
torsion thread. I mean this soft, silky-looking material—spun glass. The photograph (Fig. 6, p. 830) shows it to be fairly regular, and to be one-thousandth of an inch in diameter. This spun glass is a remarkable material in many ways. Experiments made in the physical laboratory at South Kensington by Messrs. Gibson and Gregory, show that it is stronger than it ought to be if its diameter only is taken into account. Their results are expressed in dynes per square centimetre, but for purposes of illustration, and because we are familiar with the strength of metals expressed in tons to the square inch, I have put their results in this form. Glass fibres about one thousandth of an inch in diameter have a strength of about 27 tons to the inch. The same glass in rods from 20 to 50 times as thick is from one-third to one-seventh the strength.

Thus it appears that though glass itself will not compare with iron in strength, spun glass

* The blocks of Fig. 1-7 have be kindly lent by the editor of "Nature."

has about the same strength as iron. On the other hand, while fine metallic wires are also stronger than they should be, I believe that when they are made as fine as possible the strength does not go on rising, but ultimately falls away again. Thus it is that spun glass is—or rather was until lately—the strongest thing of its size obtainable. This property of great strength is very valuable, because it makes it possible to suspend larger apparatus, and therefore to obtain larger effects than would be possible with a weaker material; or what comes to much the same thing, a finer fibre will carry a certain apparatus, and therefore there will be a greatly diminished torsion and increased sensibility. Other points in favour of spun glass are its uniformity, its freedom from atmospheric influence, and the fact that pieces of almost any length may be obtained.

Fig. 6.



There is, however, one very serious defect, which is so pronounced as to make this otherwise splendid material absolutely useless in instruments of precision. Suppose that the thing suspended carries a mirror, by means of which the deflection can be accurately observed. Now it is found that when all has come to rest, if a large deflection is produced by any means, then the zero is changed; the index comes to rest in a new place, and this place is not constant but slowly approaches the old position of rest. In some experiments which I made two years ago, I found this change of zero to be about 1-430th of the deflection if the mirror were kept deflected for one minute. Now the fact that the zero is changed every time the fibre is twisted, and that after deflection it is itself variable in position, makes spun glass a useless material for exact work. I may, however, say that I have found that this defect may be partially cured, if the angles of deflection are not large, by annealing the glass in a box of charcoal at a low red heat. In the case of a fibre nine inches long, and turned one complete turn, I found the change of zero after annealing to be about one-sixth of what it was before annealing.

It is partly for this reason, and partly because the torsion of spun glass is still so great, though it is only about one-third of what a brass wire of the same size would have been, if such fine wire were obtainable, that spun glass is never used in the construction of instruments. There was until lately no means of producing torsion threads finer than spun glass, and therefore the method of using torsion has been abandoned in all the more delicate apparatus, and fibres without torsion have been looked for which might be used to suspend the movable part of the instrument, while some subsidiary means is made use of to direct and give stability to its movement.

The most perfect torsionless fibre that I know of is the spider line. In the paper by the Rev. A. Bennett, to which I referred last week, there is an account of his experiments with spider web. He found that if he magnetised a sewing needle, and suspended it by a piece of spider web 2 inches long, he could turn the upper end of the web round 800 times, and yet the needle was not deflected to a visible extent. By way of making a more delicate experiment, he heated a piece of fine harpsichord wire in a candle flame, and allowed it to cool in the magnetic meridian, so as to obtain a very weak magnet. This hung at the end of a web 3 inches long, was not moved to a visible extent when the upper end was turned 1,000 times. Finally, he attached one fibre of the feather of a goose quill to a piece of web $2\frac{1}{2}$ inches long, and then turned it by a spinning machine more than 1,100 times, but the fibre did not go round. The thread became one inch shorter.

I do not think that much use has been made of spider line, except for cross wires in telescopes, and this is remarkable, for the very elaborate investigations of Joule* show it to be a trustworthy material. Joule experimented on the threads of the diadema spider, which are especially strong. Bennett does not specify the kind of spider that he went to for his threads. The strength of the diadema threads must be very great; Joule found that they were able to carry from 24 to 27 grains before breaking, and that they would carry for an indefinite time a load of 10 grains. He also found that with change of temperature the length of the loaded thread changed also, becoming shorter when warmed and longer when cooled. It also increased in length in a moist air, and contracted again in

* Joule's "Scientific Papers," vol., i., p. 479.

a dry air. However, the amount of this change is not very great. In a dry air a thread 23 inches long, and carrying 10 grains, would not change in length more than one-sixth of an inch, on an average, for a change of temperature of 100° Fahr. In six months it did not increase by one thousandth of its length. When the dry air was changed for wet air, the filament at once became half an inch longer. The length of diadema web does not seem to be subject to more uncertainty than the length of silk under the same conditions. If this diadema thread is as free from torsion as the spider thread used by Mr. Bennett, it would seem to be a perfect material for use in exact instruments. Why it is never* used I am unable to say. Joule speaks as though he used it in his arrangement of dip-circle, in which the needle is slung upon two loops of filament; but he says in the description of this instrument that he used silk.

Silk, as produced by the silkworm, consists of a pair of threads gummed together, about a two-thousandth of an inch in diameter apiece (Fig. 7). The silk must be washed in hot water to remove the gum, and the two fibres separated. The single fibre, according to A. Gray,* will carry a weight of about three or four grammes before it breaks, and will safely carry needles weighing from half to one gramme. The strength is approximately 340×10^7 dynes to the square cm., or 22 tons to the square inch. Though finer than spun glass, it is not quite so strong; it has a strength approaching that of ordinary iron. Silk has until lately been the material always used in instruments of the highest degree of precision. It has many valuable properties, but it is worse than glass in some respects. The torsion is so small that it is quite a usual thing to ignore it, though of course this should not be done in accurate experiments. Gray has given the results of his measures on the torsion of silk. Owing to the irregularity in the diameter, and the fact that it is not round, the figures are subject to a good deal of variation; however, they are worth giving, as they will be useful for purposes of comparison.

Fig. 7.

He finds that fibres from ·0009 to ·0015 centimetre in diameter have a moment of torsion of from ·00091 to ·0025 dyne-centimetre units. These measures give as the coefficient of torsion of the silk material numbers ranging from $1·39 \times 10^9$ to $·495 \times 10^9$; or a rigidity of $·885 \times 10^9$ to $·316 \times 10^9$ when expressed in C.G.S. units. The rigidity of spun glass, found by Messrs. Gibson and Gregory as the mean of a large number of experiments, is 205×10^9; so that it would appear that glass is from 230 to 650 times as rigid a material as the substance of which silk is made. Joule found that silk behaves much in the same way as spider thread when subject to heat and moisture.

The figures I have given are sufficient to show that the torsion of silk must be very small. Since it has a diameter about half that of spun glass, the torsion on this account would be one-sixteenth; and since the rigidity is so much less as well, the actual torsion is from 4,000 to 10,000 times less. We have already seen that the torsion of spun glass itself is so small that very feeble forces can be measured with it, but the torsion of silk is many thousand times less. No wonder that, since it is also as strong as bar iron, silk is nearly universally used.

It is, or rather was, universally used, because there was nothing better; good as its properties are, minute as its torsion is, I do not know any one who is altogether satisfied with it. The figure which represents its rigidity is true enough, and yet it is hopelessly delusive. Though the torsion, actually, is small, it is not constant, every variation of temperature or of moisture sets some new power in action so that the position of rest is never the same. This cannot be corrected by increasing the length of the fibre, because the uncertainty of the position of rest may be increased in the same proportion. Finally there is the same kind of elastic fatigue that I have described as making spun glass useless, and in a far higher degree, but the actual disturbing force here is so small that it is sometimes overlooked, though it absolutely prevents any galvanometer from

* Mr. Bottomley has told me since these lectures were delivered that he has found the spider line invaluable for suspending the mirror of a very delicate galvanometer.

* "Absolute Measurements in Electricity and Magnetism."

approaching the accuracy that would be obtainable with a perfect fibre.

Mr. Bosanquet, in a short article* which attracted a good deal of attention at the time, says:—

"At certain times the needle of the galvanometer would move about with sudden and capricious movements, the mirror often traversing several degrees of the scale. The decision and sharpness of the movements were very remarkable, and we habitually spoke of their cause as the 'ghost.' The ghost used to visit us mostly in summer, between the hours of nine and eleven in the forenoon, and six in the evening; when these movements began it was no use attempting to work with the galvanometer. There can be no doubt that the movements were due to the solar heat falling more or less directly on the instrument, and causing hygroscopic changes in the silk fibre."

He concludes the article as follows:—

"It is my conviction that silk and thread suspensions are sources of error and inconvenience to an extent that has been imperfectly realised; and that they ought to be entirely banished from all instruments of precision."

Mr. T. Gray,† who advocated the use of silk, while admitting that silk is not perfect, employed language which is hardly as strong as the subject deserves. He said:—

"When a galvanometer is made sufficiently sensitive for the fibre to play an important part in directing the needle, the set of the fibre, due to continued deflection, always produces an apparent change of zero which, in exact measurements, it is somewhat difficult to properly allow for."

Mr. Gray went on to say that the error is small, except in very special cases, and is in no way capricious. I believe I express the general feeling among experimentalists when I say that the behaviour of silk under ordinary circumstances appears, whether it really is so or not, extremely capricious.

Now, having insisted on the defects of the nearly universally-employed material, silk, I will next propose the remedy which I described before the Physical Society,‡ and which my later experience, confirmed by that of others, shows to be a remedy which is complete.

In my experiments on the development of the radio-micrometer, of which I shall speak this day fortnight, I required a torsion fibre finer than spun glass and free from the vagaries of silk. I required a thread with a torsion no greater than that of silk, of great strength, and more perfect if possible than glass or any of the metals in its elasticity. Such a thread, if found, would be valuable not only for my experiments, but for almost all investigations, the accuracy of which is limited by the defects of our present apparatus.

My first endeavours were to make glass fibres finer than spun glass, and I concluded from my experiments that the conditions for success were a very small quantity of melted glass, a very high temperature, and the instantaneous production of a very high velocity. These conclusions I tested by the very simple process of attaching a fine rod of glass to the tail of an arrow, and then, when a bead had been melted with the oxy-hydrogen jet as large about as a pin's head, shooting the arrow over the longest range that I could conveniently make use of. Under these conditions the bead of glass remains suspended in mid-air under its own inertia, while the arrow goes on its journey; but when the arrow has struck the target, there is found floating in the air, far too fine to fall quickly, a delicate thread of glass, no thicker sometimes than a single spider line. If, instead of glass, a fine rod of melted quartz is fastened to the arrow, held at the free end with the fingers, and heated to the highest temperature attainable with the oxy-hydrogen jet, then a thread of quartz can be produced in the same way, and, as you see, the process is perfectly simple and easy. [A quartz fibre was then shot, and its existence made evident by fastening to it a gummed label.]

Now having obtained quartz threads, it is necessary to describe their properties. In the first place they can be made as fine as anybody is likely to want them; threads as fine as one ten thousandth of an inch are perfectly manageable, and can be had in pieces yards long, if required. Threads as fine as one hundred thousandth of an inch can be made, but are not easy to handle. This will be the more readily understood when I say that a bundle of 10,000 of such threads would be no larger than a single piece of spun glass. How fine the finest ends of some of the fibres that I have made may be, there is no means of telling. Dr. Royston Pigott, F.R.S., believes them to be less than a millionth of an inch in diameter, and I have concluded from their appearance in the microscope—but this is hardly the right expression, for I have not been able to trace them to their end because they are far too fine—that they cannot be much more. These certainly

* "Phil. Mag.," Dec., 1886.
† "Phil. Mag.," Jan., 1887.
‡ "Phil. Mag.," June, 1887.

cannot be handled or used as torsion threads. As it is impossible to realise what numbers such as a million really mean, I may say that a piece of quartz one inch long, and one inch in diameter, would, if drawn into thread one millionth of an inch in diameter, produce more than sufficient to go all round the world 650 times, or an express train travelling without ceasing would take thirty years before it could unwind this amount if wound on a reel.

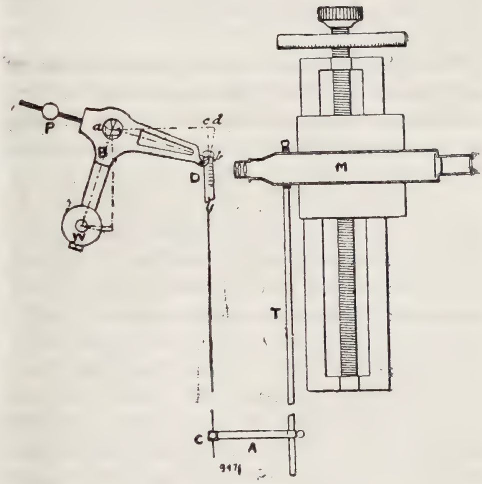
The next quality that I must refer to is the strength of quartz threads. Experiments made with great care by Mr. Highfield and myself in the physical laboratory show that, as in the case of glass, these threads became stronger in proportion to their size as they are finer. A quartz fibre rather finer than spun glass, with a diameter of 6·9–10,000ths of an inch, has a strengh of 8×10^9 dynes to the square centimetre, or of 51·7 tons to the square inch. A fibre with a diameter of 19-100,000ths of an inch has a strength of $11 \cdot 5 \times 10^9$ dynes to the centimetre, or 74·5 tons to the inch. This is a great deal stronger than ordinary bar steel. Thus quartz fibres have the two valuable properties that they can be made as fine as you please and are of enormous strength. We have also found that when the outside of fibres of spun glass or quartz is dissolved with hydrofluoric acid, the strength goes on proportionately increasing as they get finer, showing that in the case of fine fibres the great tenacity is not due to a vitreous skin. Fibres, originally of various sizes after being dissolved away till they have the same diameter, have approximately the same strength, which shows that the great strength of fine fibres is not due to their being formed under pressure. (The pressure due to a surface tension equal to that of water would in a fibre one millionth of an inch in diameter be equal to 60 atmospheres, and in thicker fibres less in the same proportion.) These experiments point to the conclusion not verified in other ways, that there is something analogous to surface tension in the solid fibre.

The next point to consider is the elasticity of the fibres both to stretching and to torsion. Experiments in this direction, I hoped, might throw some light on the cause of the enormous strength of fine fibres. I have on the table the apparatus that I devised for this purpose (Fig. 8).*

* The block of this figure has been kindly lent by the Editor of *Engineering*.

The apparatus made by Hilger consists of a microscope cathetometer shown in the figure at M, which can be made to traverse a vertical slide by means of a fine screw having a micrometer head, the divisions of which are capable of being read directly to the one-thousandth of a millimetre. To the end of the microscope farthest from the eye-piece is attached the vertical tube, T, which carries at its lower end an adjustable arm, A, fitted with a clamp, C. To the end of a separate bracket is fixed the block, *a*, which supports, by means of a knife-edge, the beam, B, which is weighted with a gravity-bob, W, and carries on a second knife-edge, *b*, the micrometer scale, D, the opposite end of the lever being counterpoised by the adjustable weight, P. The fibre to be tested has attached to it a pin at each end to facilitate its being fixed in the apparatus, it being stretched vertically between the scale, D, and the clamp, C.

FIG. 8.



When the micrometer head is turned, the cathetometer, M, is lowered, carrying with it the tube, T, and thereby putting a tensile strain on the fibre, which draws down the lever, B, being itself stretched under the increasing pull of the lever. The extension of the fibre is measured by the movement of the scale, D, across the field of the microscope, and the deflection of the lever, B, is a measure of the force that is being applied to the fibre, which is obtained by subtracting the amount of extension of the filament from the distance traversed by the microscope, which latter may be determined with the greatest accuracy by the readings of the micrometer head.

In adjusting the instrument the slide is first

made vertical by levelling screws, the accuracy of the levelling being determined by means of a spirit level placed in different azimuths on the top of the micrometer head. The counterweight, P, is next adjusted until the knife edges at a and at b are both in the same horizontal plane, and this adjustment is made when the scale D and the upper attachment pin of the fibre are in their proper position, and the microscope is focussed so as to give a sharp definition of the divisions on the scale. The fibre having been attached to the upper supporting pin and suspended in its place, the length of the arm, A, is so adjusted that the lower supporting pin of the fibre hangs freely in the axis of the clamp, C, which is then tightened, and thus perfect verticality at the commencement of the pull is ensured. The micrometer head is then slowly turned, readings being taken as each division of the scale D traverses and coincides with the cross wire of the microscope, and the force which thus extends the fibre by each increment of one-twentieth of a millimetre is determined in the following way.

If the adjustments of the instrument have been made in the manner described above, the moment due to a vertical pull is proportional to the cosine of the angular displacement of the beam, while that due to the gravity bob and the other portions of the beam varies as the sine of that angle, the actual tensile force applied at D being proportional to the tangent of the inclination of the beam. The vertical distance $c\,b$ is a measure of the sine of the inclination, and when the angular displacement is small this distance is practically the same as the tangent of the angle, and it may be corrected to measure the tangent if very great accuracy be required. The true value of the force corresponding to various values of $c\,b$ may, however, be more easily found by attaching weights to D, and observing, by means of the microscope and scale, the weights which produce corresponding deflections.

In this instrument there are two apparent sources of error, which, however, do not in any way affect the accuracy of the measurement. In the first place, it is evident that as the beam is deflected, the point b becomes more and more distant from the microscope, and the pull on the fibre ceases to be vertical, but it must be also noticed that in doing so the scale D is carried out of the focus of the microscope, which has in consequence to be adjusted by being moved forward to the exact amount which the scale had receded by the movement of the beam, and thus the arm, A, carried by the end of the microscope is moved forward to an equal extent, the scale comes again into focus, and the fibre becomes again vertical.

Again, in the case of the tube, T, being very long, it might happen that the spring of the tube and of the arm, A, might cause the fibre to appear more stretched than it really is, but the error due to this cause can be perfectly eliminated by finding, in the course of the experiment, the force that is being applied to the fibre, and afterwards placing weights on C until a pull of the same amount is obtained. As a matter of fact, however, with ordinary fibres, the further movement of D under these circumstances is not observable.

Messrs. Gibson and Gregory used this apparatus for a very large number of experiments, which they conducted with great care and exemplary patience. They examined fibres both of glass and quartz. The mean value of Young's modulus found for spun glass is $5{\cdot}16 \times 10^{11}$, and for quartz about 6×10^{11}. The modulus of torsion was observed in the usual way, with the following results:—Spun glass, $3{\cdot}22 \times 10^{11}$; quartz, $3{\cdot}74 \times 10^{11}$. The rigidity (obtained by dividing these figures by $\frac{\pi}{2}$) is for spun glass, $2{\cdot}05 \times 10^{11}$; for quartz, $2{\cdot}38 \times 10^{11}$.

There seems a good deal of variation between different specimens, but these figures go to show that the elasticity of spun glass is much the same as that of glass in mass, and that quartz is very slightly stiffer than glass.

The only serious fault of glass fibres is the fatigue, which I experimentally showed in the early part of this lecture. I shall now perform the same experiment with quartz, and it will at once be evident that the fatigue of quartz, if it exists, is nothing in comparison with that of glass. As a matter of fact, this fatigue does not cause a change of zero of 1-50 of the corresponding change in the case of glass, and it may be less; but practically it is quite beyond our power of observation to detect any effect with such deflections as are met with in the practical use of instruments.

Quartz, then, has these properties. It is, when in fine threads, stronger than the metals, and so a finer thread of this material will carry a given weight than can be made of any other material. The torsion of quartz is but little more than that of glass and is less than a

third of the torsion of steel, therefore the small torsion due to a very fine fibre is made smaller still on this account. Then since it is practically free from fatigue, since it is not affected by moisture in the air, nor liable to all the vagaries for which silk is so famous, and since it may be easily made in pieces of almost any length, there is no reason why silk should still be used. I have now for some time been making experiments with quartz fibres, that would have been, as far as I know, quite impossible with silk, without meeting with any trouble, and to me it seems, in the light of my experiments, to be unwise to use silk in instruments of precision. I may add that I am not trying to find a market for anything of mine, for these fibres are not patented—they are free to the world to use.

As an inventor or discoverer is apt to form too favourable an opinion of anything that he may have done, I shall refer to the experience of others with quartz threads.

Professor Threllfal has found it possible to improve the galvanometer by various modifications until it is from 100 to 1,000 times as accurate and delicate as a measuring instrument as any that can be made in the usual way. It was only when he used quartz that he was able to make any real advance; with silk instead of quartz his instrument was practically no better than any other. This experience I particularly value because he was very sceptical as to the truth of what I had said about the value of fibres of quartz.

Professor J. Viriamu Jones writes:—"You may indeed say that I find the quartz fibres an advantage after silk. I could not get in my low-resistance galvanometer (with an ordinary Elliott needle) a constant zero with a period of oscillation of three or four seconds; with your fibre I can get constancy with a period of at least twenty seconds. It has always seemed to me that in a very weak field a galvanometer needle suspended by silk indicates that the silk twists and untwists in the most unreliable and variable manner. Your fibre, on the contrary, in the weakest field I have put the needle in, maintains constancy of equilibrium. ....You are a benefactor of mankind."

These are not the only instances in which my experience has been fully confirmed by others. It is in consequence of these independent opinions that I have ventured to express myself in the way that I have with regard to silk.

There is another property of quartz fibres and rods which may be found to be of some importance. A stick of clean quartz in a damp atmosphere is an almost perfect insulator, while a piece of glass is, judged by the behaviour of the leaves of gold, an almost perfect conductor. Not only may quartz be used in a damp air, it may even be dipped in water, and gold leaves may be hung on it immediately, when it will be found to insulate just as well, even though the water is still visibly clinging to it.*

This high insulation of quartz, even in a wet place, may make it possible to construct electrostatic measuring apparatus which will always be ready for work, and in which sulphuric acid need not be used. But here I am leaving my subject. Going back to quartz threads, it is a curious fact that the ends of many of these become highly electrified in the process of manufacture. Whether it is the friction in passing through the air, or whether it is electrification produced in the oxy-hydrogen flame, I do not know, but the fact remains that the floating ends of some of these threads are very highly electrified, and the electricity, small in amount on account of their extremely small capacity, is absolutely unable to escape, but it makes its existence evident in a very curious way. The ends of these fibres, as seen floating, often assume a spiral or wavy form, and these screws serve as excellent instruments for revealing the presence of electrification, which I believe is too small in quantity to show on any apparatus. If you gradually approach the hinder end of one of these electrified screws it suddenly shoots itself out, and the fibre is projected on to the approaching body. This may be repeated several times.

It is for this reason, I believe, that it is possible to gather the extraordinary material which you now see upon the screen. If you take a strong oxygen hydrogen jet, and keep joining and separating two sticks of quartz in the flame, a very great length of a complex cable is shot away, but it is so fine that it will float away and be lost. If, however, you place in the line of the flame, but a foot or two away, a retort stand or other convenient support, you will find this covered with long threads of this multiple cable, consisting of fibres of all sizes, from one five-thousandth of an inch downwards. By varying the size of the flame, the proportion of the gases, and the place at which the quartz is held, you can produce anything between this complex cable, down to those fine tapering tails which no microscope can follow to the end.

The following hints may be of use to those

* "Phil. Mag." Aug., 1889.

who are going to mount apparatus upon fibres for the first time. Having chosen a fibre of the right diameter, and longer than is ultimately required, the first thing to do is to fasten a small fragment of gummed stamp paper to one end. This acts as a weight, and makes the following processes more easy. The upper, or fixed support must next be fastened to the free end of the fibre. I prefer a common blanket pin passing through a cork to any of the more elaborate contrivances in common use; however, whatever is going to be used for the fixed support should be pointed at the lower end.

If the needle or other thing to be supported is very light, *i.e.*, nowhere approaching the breaking weight of the fibre, shellac varnish is the best thing to use as the cement. Just moisten the last five millimetres above the pin with this varnish, and—holding the fibre near its free end in one hand, and the pin in the other, with the little finger of one hand resting against the little finger of the other, for the sake of steadiness — immediately apply the fibre to the varnished surface, to which it will stick. Then pull it endways through a distance of half a millimetre about, to make sure that when all is dry there will be no sudden bend in the fibre. A hot piece of wire, or knife, or pair of pliers must then be applied to the pin above the varnish, so that the heat may be conducted down slowly to drive off the remaining alcohol and melt the shellac. After this the fibre is securely held at that end.

If the thing to be supported is very heavy, varnish is not so good as melted shellac, but this is much more difficult to apply. The pin must be warmed and smeared near the joint, and while hot the fibre must be applied and slightly pulled. Whether varnish or melted shellac is used, it is essential to work in a proper light. A table in front of a large window in the day, or supporting one or two movable gas burners at night, will do perfectly provided that a really black background exists, upon which the fibre may be made evident. Black velvet, or paint, or paper is no use whatever. The only background that does well, and one that is easily arranged, is the darkness inside a drawer just pulled out an inch or two.

Assuming that one end of the fibre is properly fastened, the next thing is to determine the exact length required. For this purpose I always make a drawing on a perfectly clean and smooth board, showing the point of the pin at one end, the extreme end of the thing to be supported, and the position of the mirror or whatever determines the length of the fibre.

The holding-pin is then raised up until the paper weight is hanging in the air. This is then allowed to rest on the board, and slowly dragged along until the point of the pin is exactly over the corresponding mark on the board, and the paper wafer is in the line of, but beyond, the other mark. The fibre is then straight, and must pass over the mark which indicates the upper end of the apparatus that is to be suspended, though, of course, nothing can be seen. A knife is then drawn across the board, say five millimetres beyond this mark. By this means the fibre is cut, and the five millimetres are left for the purpose of attachment. The needle or suspended thing is then fastened in the same way as the pin. It is well then to drag the needle along until the mirror is exactly over its place on the drawing, and see if the upper pin is also in its place. By warming either pin, and pulling the fibre, a slight alteration can be made if necessary.

The paper weight with the remainder of the fibre may then be taken up, and the free end fastened on a microscope slide and labelled, so that the diameter of the fibre may at any time be found. If the fibre, illuminated by a distant light, had been examined with a prism first, and the dark bands of the spectrum had been found straight and uniform from one end to the other, and it is only such fibres that I use, then the diameter must be the same over the whole length.

Though I have given a large proportion of the time at my disposal to this one part of the subject, I hope that it will not be considered that I have occupied more time than is demanded by the importance of the subject or the value of the results, of which some are now published for the first time.

Miscellaneous.

*TELEPHONIC COMMUNICATION BETWEEN LONDON AND PARIS.**

The author said the question of telephonic communication between London and Paris had very much occupied the attention of electricians in Paris as well as in London. A desire to establish this communication had arisen with the Minister of Posts and Telegraphs in Paris. They had devoted a great deal

* Abstract of a paper read by Mr. W. H. Preece, F.R.S., before Section 9 (Mechanical Science) of the British Association.

of attention to it, and it had occupied much of his time lately. The distance between London and Paris was 275 miles, made up by 74 miles from London to Dover, 21 miles from Dover to Calais, and 180 from Calais to Paris. The mere act of speaking by telephone over a distance of 275 miles was practically nothing. Distance in telephonic matters scarcely entered into the question at all. If they had a wire, or two wires, from the earth to the moon they would probably be able to speak with the inhabitants of the moon, if there were any. The difficulty was one that arose from the character of the materials used, and from the presence either of underground wires or submarine cables. It happened that between London and Paris they had to deal with the difficulties of underground work in London and Paris, and the fact that they had half-way, nearly across the channel, a submarine cable. In America they had spoken from New York to Chicago, a distance of nearly 900 miles. When he was in the States, in 1884, he spoke between New York and Boston, a distance of 350 miles, and at present in the United States there were many places over 300 miles apart between which commercial telephony was carried on. He had recently been in Paris to look into this question. In Paris they had established telephonic communication, commercially and practically between Paris and Brussels, a distance of 190 miles, and anybody could go into the silence box in the Bourse, at Paris, and could make an arrangement with his friend at Brussels to go into a similar box, and they could talk together for three minutes for three francs. As a matter of fact, it was the success of the Paris and Brussels telephone that had excited the desire of communication between London and Paris. Again, he spoke between Paris and Lille, a distance of 138 miles; but the longest distance and the most interesting experiment was when he spoke between Paris and Marseilles, a distance of 600 miles. He had not the least difficulty whatever in carrying on conversation with gentlemen in the box at Marseilles. In these cases they had no difficulties like those that were met with between London and Paris. The only length of underground wire was in Paris, where it amounted to about two miles; but between London and Paris they had the underground system of London, they had several lengths through tunnels, and they had the 21 miles of cable to surmount. There were certainly difficulties in the way, but they had succeeded in finding out what these difficulties were, and when in electrical matters they once knew what the difficulties were, the remedy was very simple indeed. As regarded cables, he had experimented between not only Calais and Dover, but between Dublin and Holyhead, and between South Wales and Wexford. These two latter cables measured 60 miles, and he had certainly been able to speak. In this district and its neighbourhood the wires were almost entirely underground. The telephonic system in Newcastle he believed to be the most perfect in the world. He visited the telephonic exchanges in America and on the Continent, and he did not think there was anywhere a system that worked with such regularity, and with such rapidity, and was manipulated so well as the telephonic system in Newcastle-on-Tyne, which had grown up under the fostering care of Mr. Arthur Heavyside, whom he saw in the room. Here they grappled with the question at once by putting the wires underground, and people had always asserted that it was impossible to work telephones underground. They found it was possible to work them to a certain distance, and they knew the distance exactly, and the only things they had to surmount were two electrical quantities. One was the capacity of the circuit, the power that it had of storing up electricity. After the current went in a certain amount of it was stored up as it were, and did not appear at the other end. The other quantity was the resistance which the wire offered to the passage of the current through it. When the product of the current and the resistance amounted to 15,000 speech was impossible; if 12,500, speech was possible; if 10,000, good; if 7,500, very good; if 5,000, excellent; and if 2,500, or under, perfect; so that they had a scale by means of which they could tell at once, given any circuit between any distances, whether speech was good or impossible. They found that, taking the ordinary conductors between London and Paris, using copper wires to the shore, in each case they would get a product which would be about 12,500. To verify that he had an artificial line, one exactly on these conditions with a portion representing the wire from London to Dover, another portion the cable, and a third portion the wires in France. The result was that speech with a product of 12,500 was fair. But it was a very difficult thing to satisfy the unscientific mind with an artificial wire in a laboratory experiment. It fortunately happened that they had coming into London copper wires from various directions, and throughout London there was an underground system of telephones, and by making a circuit from Worcester through London to Baldock, on the Great Northern line, he was able to reproduce the actual line that represented exactly these conditions which he mentioned as being those likely to be met with by using standard wires between London and Paris. The result was that they spoke with great ease, and no question whatever was left that communication between London and Paris was perfectly practicable.

Notes on Books.

Commercial Geography: Based on the Latest Researches and Statistical Returns. By Dr. Carl Zehden. Translated by Findlay Muirhead. London: Blackie and Son. 1889.

Dr. Zehden's work was first published in 1871, and it has passed through five editions in German. Some

modifications have been made by the translator to adapt it to English readers, such as the expansion of the sections on Great Britain and the British Colonies, and the corresponding abridgement of those relating to Austria-Hungary. The first part deals with Mathematical Geography, and the second part with Physical Geography, but these are only introductory to the main subject of the work, which is Physical and Commercial Geography. The information is set forth under various headings, and an index of products and manufactures of the various countries is added. The author remarks :—"In the present age, when international commerce exists no longer in the peaceful exchange of the productions of the different zones, but is often a keen life and death rivalry between competing nations and continents, the educated merchant must learn to regard the world as an economic organism, in which each nation discharges the function that best accords with its economic development. I believe that my book owes much of its friendly reception to the attempt made in it to account for the economic position of each State by its physical character, and by the ethnographic peculiarities and the degree of civilisation of its people."

LIFE OF CHARLES BLACKER VIGNOLES, F.R.S., Soldier and Civil Engineer. A Reminiscence of Early Railway History. By his son Olinthus J. Vignoles, M.A. London: Longmans, Green and Co.

The subject of this memoir died at the age of 83, so long ago as 1875, and his birth therefore dates back to the year 1793. Mr. Vignoles commenced his career as a soldier, and passed some of his early years as an assistant State surveyor for South Carolina. In 1873 he returned to England, and commenced practice in London as a civil engineer. After this he was for many years largely engaged in the construction of the railways of the United Kingdom. In 1843 he was consulted by the Wurtemberg Government on the construction of railways in that kingdom; and in 1846 he prepared drawings for the great suspension bridge at Kieff, which he afterwards carried out. It will be seen from the above that the life of Vignoles divides itself into three periods, and the author recognises these divisions in his memoir:—(1.) Vignoles's life of adventure as an officer in the British army, and subsequently in various employments in the United States of America. (2.) His work as one of the small group of civil engineers engaged in the construction of the earliest railways in England and Ireland. (3.) His foreign engineering work in Germany, Russia, Switzerland, and Spain, with a full and detailed account of the Kieff suspension bridge. The author, in summing up the results of Vignoles's life and labours, says that with him the romantic era of modern engineering science may be said to have passed away.

EXAMINATION PAPERS IN BOOK-KEEPING set at the Civil Service, Society of Arts, City of London College, and other Examinations, with preliminary exercises. Collected and written by J. F. Medhurst. London: G. Bell and Sons.

This volume contains a series of papers set by the various institutions mentioned in the title page, and these papers are preceded by some preliminary exercises to prepare the students for the later papers.

General Notes.

PARIS EXHIBITION.—The public announcement of the awards of the juries will be made on Sunday next, at the "Fête des Récompenses," which will be held in the Palais de l'Industrie in the Champs Elysées. The diplomas representing medals of various values—gold, silver, and bronze—will not themselves be distributed on this occasion, as they will not be ready for some time to come, nor is it even proposed to read out the list of the recipients. All that will actually be done will be to hand to the president of each section a list of the awards in that section. A list of the awards to the British Section, which are very numerous, will be issued to the British exhibitors on Saturday next. The total number of awards to the British Section are 910, among 1,017 exhibitors.

SILK CULTIVATION IN HUNGARY IN 1888.—The silk cultivation of Hungary, which, by the law of 1885, is exclusively in the hands of the Government, is, according to Consul Nicholson, making very good progress. The number of communes in which it is prosecuted has risen from 1,048, in 1889, to 1,389, and the number of families engaged in this business from 28,145 to 40,423. The weight of cocoons produced amounted to 703,488 kilogrammes in 1888, against 251,875 kilogrammes in the previous year, or an increase of 56 per cent. The largest quantity of cocoons ever before produced in Hungary was in 1840, when the returns showed 400,000 kilogrammes, or about half the quantity produced in 1888, and this great development has occurred within nine years, as in 1880 only 2,800 kilogrammes were produced. In the Government spinning factories at Neusatz and Pancsova, employing 539 hands, 260 spindles worked up 14,000 kilogrammes of silk out of 200,000 kilogrammes of cocoons. For the preservation of the cocoons, and the production of silk caterpillars, more buildings were erected, and with the co-operation of the Government, the silk industry is also being extended to Croatia. Owing to the low prices prevailing in the silk industry great attention is being paid to the improved methods of spinning, and in the Pancsova spinning factories reels on the Camel and Bertiol system have been experimentally introduced. The planting of mulberry trees is also being increased.

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Proceedings of the Society.

CANTOR LECTURES.

INSTRUMENTS FOR MEASURING RADIANT HEAT.

By C. V. Boys, A.R.S.M., F.R.S.

Lecture III.—Delivered April 8, 1888.

Of the instruments for detecting feeble effects of temperature, the best known are those depending on the electromotive force set up in a metallic circuit composed of different metals when there is a difference of temperature between the junctions of the metals.

The elementary metals may be arranged in a series, with bismuth at the beginning and antimony at the end, so that if a circuit is made of any two, an effective electromotive force will be found tending to send a current across the warmer junction from the lower to the higher metal in the series. The greater the difference of temperature, and the further the metals are apart in the series, the greater, in general, will be the effective electromotive force. When the temperature differences become large, it is found that the electromotive force is not exactly proportional to the difference, and in some cases not at all proportional, so much so, that if the hot junction is heated, or the cool junction cooled, beyond a certain point, instead of an increase there is actually found a decrease of electromotive force. Though these departures from proportionality can be completely represented by the thermo-electric diagram of Prof. Tait, there is no occasion to consider this at the present time, for with such very small differences of temperature as we have to deal with in thermopiles and similar apparatus, the electromotive force is, as far as experiment can show, exactly proportional to the temperature difference for any mean temperature, and the effect of such small changes of temperature as are met with in a laboratory from day to day, while very small, can, if necessary, be exactly allowed for. We may, therefore, with propriety use the old-fashioned expression, and say that the "thermo-electric power" of any pair of metals is so much, and that the further the metals are apart in the series, the greater is their thermo-electric power. Turning, then, to the tables given in the text-books, bismuth and antimony being at the two ends, have a greater thermo-electric power than any other pair of simple metals. Iron and copper, which are intermediate metals, form, at ordinary temperatures, a combination of which the thermo-electric power is about one-seventh of that of bismuth and antimony.

It is impossible at present to give any reason why the several metals should have the thermo-electric properties that they are found to possess. In the case of some of the alloys the properties are the reverse of what might be expected. Thus, though bismuth is the most positive, and antimony the most negative of the metals, an alloy composed of thirty-two parts bismuth and one part antimony is more positive than bismuth itself; though antimony is the most negative of the metals, and bismuth the most positive, and tin is nearly neutral, an alloy of twelve parts bismuth and one of tin is more negative than antimony. The first of these alloys, and one almost the same as the second, are stated by Lord Rosse* to be the alloys which, at that time, Messrs. Elliot Bros. used in their thermopiles.

I have, with the help of Mr. Burbidge, examined these two alloys, and find that at ordinary temperatures they have a thermo-electric power one-third greater than that given by bismuth and antimony. They have this further advantage, especially over antimony, that they are both easily fusible, and can be cast in thin leaves between smoked glass plates.

The electromotive force acting in a circuit composed of these alloys, when the temperature differences between the junctions is one degree Centigrade, is about one sixty-thousandth of a volt. As this is an enormous electromotive force for a delicate galvano-

* "Proc. Roy. Soc," xviii., p. 553.

meter, an exceedingly small temperature difference can be detected.

To still further increase the electromotive force it is usual to make thermopiles with a very large number of pairs of bars having their alternate junctions near together. Heat thus falling upon one side of the pile will warm the alternate junctions, so that the electromotive force due to all the pairs will be added together. In the pile now on the table, made by Elliot, there are eighty pairs of bars, and these are packed into a space only two centimetres square. Each bar has a section of about 2 × 1 millimetre.

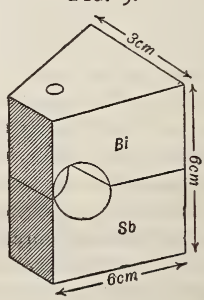
As an example of the sensibility of the thermopile, I may give the following results obtained with the ordinary standard apparatus, namely, the thermopile referred to above, and an Elliot reflecting galvanometer of low resistance made to be used with the pile. When the magnet was so adjusted that the needle had a period of oscillation of six seconds, the heat from a candle flame at a distance of five feet produced a deflection of 110 millimetres of the spot of light, on a scale one metre from the mirror, that is with the reflecting cone in position. Without the cone the deflection was 31 millimetres. The candle flame is perhaps not a very scientific or exact source of radiant heat, but it is very convenient, and serves well when the object is to compare one instrument with another. If an improvement in an instrument is of so slight a character that the small variations of heat radiated from the flame of a candle of any definite make are liable to mask its effect, then the improvement cannot be of much consequence to anybody; but if by any means an instrument can be made ten or a hundred times more delicate, then the greatest variations in the candle flame will be insufficient to materially affect this proportion, and so, for practically testing the value of an instrument, there is no occasion to set up a more constant source of radiation.

I have given the results obtained with the standard apparatus so as the more readily to trace the value of more modern development. The resistance of all the bars of the pile and of the wire of the galvanometer, though not very great, is one of the factors that determines the strength of the current. If by any means the resistance could be reduced, the current would be increased in the same proportion, that is if the temperature difference remained the same.

Professor Forbes has devised a simple instrument,* which he calls a thermo-galvanometer in which the resistance is reduced enormously. He reasoned as follows. Imagine one pile of twenty pairs, and a second having the same outside dimensions, but consisting of one pair; then for any temperature difference, if the electromotive force and resistance of the pair are each called unity, the electromotive force of the pile would be twenty, and its resistance four hundred. Now, since the resistance of the galvanometer most suitable for any pile is equal to that of the pile, the total resistance of the pile and galvanometer should be eight hundred. If now the two ends of the pair are united, and not connected to a galvanometer at all, the currents in the two cases should be, by Ohm's law, $\frac{20}{800} = \frac{1}{40}$ in the case of the pile and galvanometer, and $\frac{1}{1} = 1$ in the case of the pair; so that with a simple pair the current should be forty times as strong as with a pile of twenty pairs and a galvanometer. On the other hand, since there are many turns of wire in the galvanometer, the current may go round the needle so many times as to more than compensate for its feebleness; and though the simple pair so formed as to enclose a needle may not be more sensitive than the usual pile and galvanometer, yet on account of its great simplicity and cheapness, it may be of value in some cases.

The form which Professor Forbes gave to his pair is shown in Fig. 9, from which it

FIG. 9.



will be seen that the sectional area of the metal is very great in all parts except at the face which is to be exposed to radiation. This face is filed away until the linear junction so formed is so thin that with further filing there would be risk of destruction. The face is then

* "Proc. Roy. Soc.," Feb. 18, 1886.

blackened so as to make it absorb heat freely. A hole drilled through the upper block allows the needle and mirror, which hang within the cylindrical hole in the block, to be supported by a thread from above.

Messrs. Nalder Bros. have kindly lent me one of these instruments of their make, which Mr. Burbidge and I have examined. Whether this is a good sample of the instrument I do not know, but in sensibility the instrument is far behind the thermopile and galvanometer. That it does not come up in sensibility to the value that the consideration of Ohm's law alone would lead one to suppose is due to the following causes. In the first place, whatever is done to reduce the electrical resistance of the bars applies also to their thermal resistance, and so, since this also is reduced to the greatest extent possible, the heat which falls on the hot junction can escape freely, and so the hot junction is not made so hot by the absorption of heat at a given rate as it would be if the thermal resistance were greater. Again, when an electrical current passes in a thermo-electric circuit, heat is carried from one junction to the other by the current, and the quantity of heat which is so carried is proportional to the current strength. Since the current density in Professor Forbes's instrument is at least twice as great as in the usual arrangement, heat is electrically carried from the hot to the cold junction at at least twice the rate for a given temperature difference; and so, if this were the only cause of equalisation of temperature, the hot junction would be heated to less than half the extent above the cold that it would be if the current density were at the usual rate, However, I do not think this electrical transfer of heat is important in comparison with that due to ordinary thermal conductivity.

The only point in which my experience does not confirm that of Prof. Forbes is in the deadbeat character of the instrument. He states that on account of the small resistance of the block of metal in which the needle is suspended, the electrical currents induced by its motion are sufficient to make it dead beat. The instrument that we examined showed by no means a large decrement, in fact, the great number of oscillations of the needle were a serious inconvenience.

Now returning to the ordinary pattern of thermopile and galvanometer, the question is worth asking whether it is capable of improvement. Are the number of bars that the instrument maker happens to have employed the best number? Are the number of windings and the thickness of the wire in the galvanometer the best for the purpose? At first let the space filled with the thermo-electric metal in the pile, and the space round the needles in the galvanometer filled with wire be supposed constant, then there are two problems each of which has the same answer. They are, given a thermopile find the best galvanometer, and given the galvanometer, find the best thermopile. Let nothing be altered except the number of pairs in the pile, or of turns in the galvanometer, then all other kinds of variation due to conduction of heat, radiation, &c., or to the magnetism or moments of the needle for the time do not exist.

If the pile is made with twice as many bars, its electromotive force will be doubled, but its resistance will be increased in a fourfold ratio. The increase of resistance is objectionable, while the increase of electromotive force is the reverse. There must be some number of bars which will be most advantageous. This is the case when the resistance of the pile is equal to the resistance of the galvanometer and connecting wires. The solution of the converse problem is the same, the number of turns and size of wire should be so chosen that the resistance of the galvanometer should be equal to the resistance of thermopile and connecting wires. These results are not quite true, because of the electrical transfer of heat, known as the Peltier effect already referred to. On this account the galvanometer resistance should be slightly higher than the resistance of the thermopile, but the heat transfer due to this cause is, as already mentioned, small in comparison with that due to thermal conduction.

The solution found at present is only relative. Given a galvanometer the best pile may be found, or given a pile the best galvanometer may be found, but we do not yet know whether both should have many bars and turns of wire, or a few bars and turns. Judging by the practice of instrument-makers, who crowd eighty pairs of bars into so small a space, a great number would appear to be best.

Now, imagine a thermopile and galvanometer exactly suited to one another, and a second pair of the same pattern in every respect, except that they have just half as many bars and half as many turns of wire, each filling, of course, the same space. Then the total resistance in the second case will be one quarter the resistance in the first, while the electromotive force will be one half; the

current therefore will be twice as strong, but as it goes round the needle only half as many times it will produce exactly the same effect.

This is a really true comparison, for the Peltier effect, heat conduction, radiation, &c., are the same in both cases, it therefore follows that since half the number of bars and turns is equally good, the same will be true of half the number again and so on, until there is either only one pair of bars in the pile, or only one turn of wire in the galvanometer. It would, therefore, appear that all the trouble and expense of making so many pairs of bars in a thermopile is a waste, and that one pair is just as good as a million. This result is only true so long as the resistance of the connecting wires is sufficiently small to be neglected. If, as is sometimes necessary, the thermopile is some distance from the galvanometer, and if also flexible wires are essential, then, owing to the resistance of the connecting wires, many bars should be used, for just as they are increased in number does the resistance of the connecting wire interfere less and less. There is another reason of greater practical importance why many bars are advantageous, and that is that as the working electromotive force of the pile is increased, so, in proportion, do accidental electromotive forces produce less disturbing effects. For instance, at every binding screw there is a thermo-electric junction, at which accidental temperature changes, due to hot or cold draughts, handling, &c., set up electromotive forces, which may be exceedingly troublesome. Or, again, if the connecting wires are any of them apt to swing about, each one in cutting through the earth's magnetic field will cause an electromotive force to be set up which may largely disturb the galvanometer needle.

It is only in the cases where these disturbing causes are met with that any advantage is gained by the use of a large number of bars. If they can by any means be avoided, then a single pair of bars does just as well as a large number.

The next thing to consider is whether the single pair, which is as good as a pile of eighty pairs if the galvanometer and connections are properly arranged, and which is at present supposed to occupy the space of eighty pairs of bars of the usual size, can be made more effective by increasing or decreasing its sectional area, its length remaining the same. Let it be reduced until it is half the thickness and half the breadth, then its resistance will be four times as great as it was, and the galvanometer, altered so as to have four times the resistance also, will have twice the number of turns. If it is possible to concentrate all the heat which would have fallen on the larger surface, also upon the smaller, then, since practically all the heat which falls on the hot junction is carried away by conduction, by radiation from the face, and by the Peltier action of the current, which each now go on at one quarter the rate for any given difference of temperature, the hot end will acquire four times the excess of temperature; the current, therefore, will be the same, but it goes round the needle of the galvanometer twice as often, and so the deflection will be doubled. In the same way, if the bars are made ten times as small each way, the deflection will be ten times as great.

If, on the other hand, the bars received the proportion of heat due to their smaller surface, that is one quarter and one hundredth in the two cases, then the deflections would have been one half and one tenth instead of two and ten.

Lord Rosse* has obtained the effect of concentrating on the ends of small bars the heat which corresponds in quantity to the area of large bars by simply soldering the ends of a pair of very thin bars to the centre of a thin disc of copper, the opposite face of which is blackened to receive the radiation. He found that with thin copper discs half-an-inch in diameter there is hardly any loss of effect, owing to the want of perfect heat conductivity in the copper. This plan has the further advantage that the soldered surface or junction is on the heated surface, and not, as usual, buried to a depth of a millimetre or so in the pile. In the latter case a superficial warming gives rise to currents which partly return at the back of the warm junction so that the full current to the galvanometer is not produced until the pile is heated to the bottom of the junctions. Lord Rosse fully realised the advantage of small bars, a single pair of which he has used in his investigations on the heat of the moon. He has experimentally verified the conclusions which he found theoretically to be necessary, namely, that as the bars are made thinner, the junction not only produces a greater effect upon a suitably arranged galvanometer, but, in addition, the final temperature, and, therefore, the steady current is much more rapidly developed.

For some purposes the smallest heat receiving surface is sufficient, as in the experiments

* "Proc. Roy. Soc.," xviii, p. 553.

of Dr. Huggins and Dr. Stone upon the heat of the stars. In this case the image of the star produced in the telescope is so small that all the heat can be brought to a surface no larger than the point of a pin, so here especially is a single pair, and that as fine as possible better than any pile.

By this reduction in the size of the bars one of the disturbing elements in the argument that has been used is made of less importance, I mean the effect of the resistance of the connecting wires. If the bars could be made so fine that their resistance would be equal to that of an ordinary pile, then the resistance of the connecting wires would, for the purpose of comparison, be eliminated.

Wishing myself to put this argument to the test of experiment, I devised and made a special form of junction on Lord Rosse's plan, but with bars made of the alloys already described far finer than have been used before. They have a section of about one-twelfth of a millimetre each. They are soldered at one end to a piece of copper foil about one-third of a square centimetre in area, and at the other end to two large pieces of copper foil, separated by mica and pressed together. This is to ensure that the unexposed ends of the bars shall be at the same temperature, and that any uncertainty due to heat brought to one bar more than the other by the connecting wires shall be eliminated. As the bars are so fine that they could not carry the copper foil without risk, amounting almost to certainty, of being broken, I have had to support the copper foil independently by slinging it on stretched fibres of spun glass. These hold it securely, but do not carry heat away from it to any appreciable extent. Connecting this junction with the galvanometer that was made for use with the pile of eighty pairs, a galvanometer which is not at all suitable, we found that a candle flame five feet away produced a deflection of eleven millimetres, or one-third of the deflection produced by the pile. The exposed surface was, however, only one-twelfth of that of the pile. It appears, then, that the pair with an unsuitable galvanometer did four times as well as the pile with its own galvanometer.

Mr. C. C. Hutchins has given a short account* of an instrument which is simply a junction of steel and copper ribbon 1 × ·03 mm. at the focus of a concave silver on glass mirror eight millimetres in diameter. He states, as a record of its performance, that the hand held six inches away produces a deflection of 30 divisions, and a lighted match at six feet drives the needle to the stops. I do not think Mr. Hutchins has done justice to the idea, for with such metal as steel and copper he might have made them far thinner, or with a thickness but little greater he might have used the alloys of bismuth, which have a thermo-electric power seven times as great.

It is necessary to use a galvanometer with a thermopile, and the delicacy of the former is just as important as the proper construction of the latter. In the first place, assuming that the ordinary form of galvanometer is to be used, the question arises—With what size of wire should the coils be wound? What is required is that the galvanometer should be so wound as to have some predetermined resistance, and yet have as many turns of wire as possible, especially near the inside, where each turn produces a far greater effect than one of the outer turns. Clerk Maxwell has shown that so long as the insulating layer occupies a small proportion of the space filled by the wire, which is nearly true in low resistance galvanometers, or that it has a thickness proportional to the thickness of the wire, the best effect is obtained when the diameter of the wire is made to vary in direct proportion to its distance from the axis. A coil so wound is said to be graded. Of course, in practice, a new size of wire is not taken for every layer, but a few sizes are employed in their proper places.

The next question that may be asked is—Why should the ordinary size of coil be selected? Why should its interior or exterior limits be just those commonly used? Imagine two coils geometrically similar in all respects, but one of four times the dimensions of the other, then the number of turns in each will be the same, the resistance of the small one will be four times as great as the resistance of the large one, and the magnetic field at the centre of the small one will for a given current be four times as great as the field in the large one. Now, to make the coils strictly comparable, they must each be made of the same resistance. If the number of turns in the small one is halved, the resistance will then become the same as the resistance of the large one, and so the same current will be sent through it as through the large by any pile with which it may be connected. The magnetic field at the centre, however, will now be twice as strong in the small as in the large coil, and therefore the deflection will

* "Phil. Mag.," Jan., 1888.

be twice as great. If the space occupied by both coils, so formed as just to fit within one another, were filled with wire, graded, and of such a size as to have the same resistance still, then the magnetic field at the centre would be $\sqrt{5}$ or 2·24 instead of 2, that of the large one alone being considered unity; so the relative deflections produced in the three cases and the weights of the coils would be:—

	Large coil.	Small coil.	Both.
Deflection	1	2	2·22
Weight..........	256	1	257

The figures given for the double coil hardly represent the best that could be obtained with such an extended coil, because the shape is not of the best; but, while a slight advantage could be gained by employing also the best shape, the figures are sufficient to show what a great advantage is obtained by reducing the interior of the coil, and how little is gained by enlarging it outwardly.

Since the needle or needles of the galvanometer must be suspended within the coils, it is evident that it is not possible to reduce the aperture in the coils without at the same time reducing the needle also. The question then arises whether shorter needles have any advantage. If the needles are reduced to half their length their moment of inertia will be reduced to one-eighth of the previous amount, while the magnetic moment will be reduced to one-half, or perhaps to rather more than half. If the controlling force which brings the needle to rest, whether due to a magnetic field or to torsion, is so modified as to give any definite period, then it will have to be proportional to the moment of inertia, and will therefore, in the case of the short needle, be one-eighth of what it would have to be in the needle of double length; the consequence is that under these conditions—that is, of definite period—a given current in the coils will produce a deflection four times as great in the smaller needle. If both coil and needles are reduced in the same proportion, that is to $\frac{1}{n}$ of the original size, then resistance and period remaining the same, the deflection due to a given currrent will be $\sqrt{n^5}$. The only reason why this general reduction of dimensions has not been made before is that as the needles are made smaller or shorter, the irregularities of the silk suspension become of greater importance, so much so, that with needles only half the length, and with the same period, the disturbance would be eight times as great, and so for other dimensions in the proportion of the inverse cube. As it is, with the ordinary size of needle used in the galvanometer, the effect of the silk is sufficiently obvious with slow periods, and so no good would result from further reduction, but rather harm. On the other hand, with a quartz fibre, the full advantage of the smallest galvanometer that can be made is readily obtained.

There is another question in connection with the galvanometer, namely, whether it is best to use an astatic combination or a single needle. If the astatic needles are each placed as usual within coils, then in a low resistance galvanometer the deflection would be only $\sqrt{\frac{1}{2}}$ or about ·7 times as great as it would be if the same current were passed round a single coil of the same size, and of the same resistance as the two with only one needle, provided that the period of oscillation remained unchanged, or with a second needle outside the coil, the deflection would be rather more than half of this latter result. I have here supposed that the moment of inertia of the mirror is not more than a small fraction of that of the needle.

To put these conclusions to the test of experience, I have made a very small galvanometer, with a coil about the size of a threepenny bit, with a triple needle within it. The needle was rather less than three-sixteenths of an inch long, and weighed, with the mirror and connecting stem, less than three-quarters of a grain. This was suspended by a fine quartz fibre three inches long, and I had no difficulty, partly by screening and partly by a counteracting magnet lying on the table, in almost immediately producing a period of as much as ten seconds. This little galvanometer was connected with the thermo element already referred to, which was exposed to a candle at five feet. The deflection obtained when the period of oscillation was about seven seconds was 67 mm., while with a period of ten seconds it was 126 mm. Since the heat received is exactly one-twelfth of that which would fall on the pile placed at the same distance which produced a deflection of 31 mm. on the standard pattern galvanometer, it is evident that with the same amount of heat the standard instrument would have produced a deflection of $2\frac{1}{2}$ mm. only, and so it appears that the combination of simple element and very small galvanometer is from 26 to 50

times as sensitive as the much more elaborate and expensive apparatus which is always used.

Though a single needle or group of needles is certainly preferable to an astatic combination, where sensibility only is the object, or where disturbing magnetic changes do not occur, there is a great practical advantage in using an astatic system in most cases, because if there is a slight magnetic disturbance, whether due to natural causes or to the movement of iron in the neighbourhood, the effect is by no means so marked when an astatic, or nearly astatic, combination is used, as when a single needle is suspended in a field where the earth's magnetism has been almost entirely neutralised by an adjustable magnet.

There is one other consideration on which I have at present only very lightly touched, and this is the time that elapses after the heat falls upon the instrument before a fairly steady reading can be obtained. This is generally determined by the mass of the junction or junctions which have to be heated. These go on rising in temperature until the loss of heat is equal to the gain. The greater the mass the longer in general is the time that must elapse before a steady temperature is obtained. In some cases, especially when the galvanometer needle has a long period and a slight logarithmic decrement, and when the mass of the thermo-junction is but small, the time of coming to rest may depend chiefly on the galvanometer.

Mr. Burbidge and I have determined this time in the case of the various instruments referred to in this lecture. The figures are of necessity mere approximations. They are:—

	Seconds.
Thermo-galvanometer	200
Elliot's pile and galvanometer	120
The small thermo-element and Elliot's galvanometer	30
The small thermo-element and the small galvanometer	60

These figures are important, not so much because if an instrument requires twice as long before a reading can be obtained than another it will also require twice the quantity of heat on this account, but because time is a very important factor when heat measures have to be made under the usual variable conditions. If a measure can be made in half the time, the uncertainty of the position of rest due to changes of temperature which cannot be prevented, is certainly on the whole not more than half what it would be in the double time—it may be even less—and so the accuracy or degree of trustworthiness is greater in proportion as the time which it is necessary to wait is less.

Mr. Burbidge has prepared the following Table, which shows in round numbers at a glance the value of the several combinations described in this lecture:—

	Actual Deflection.	Deflection. / Heat received.	Deflection. / Heat × time.
Thermo-galvanometer (with cone)	$\frac{1}{2}$	$\frac{1}{10}$	$\frac{1}{15}$
Do. do. (without cone)	$\frac{1}{24}$	$\frac{1}{5}$	$\frac{1}{4}$
Elliot pile and galvanometer (with cone)	$3\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$
Do. do. (without cone)	1	1	1
Pair with Elliot galvanometer (without cone)	$\frac{1}{3}$	4	$17\frac{1}{2}$
Do. small do. (without cone)	2	24	48

The falling off of the figures in the second and third columns, where a reflecting cone has been used, shows that it fails to usefully reflect all the heat which falls upon it. It ought never, in my opinion, to be used when definite results are required. I do not lay any stress upon the exact value of these figures, especially those in the third column; but, taking the ordinary apparatus without a cone as the standard of reference, the figures are sufficient to confirm the conclusions to which the argument which I have followed in this lecture has led.

Miscellaneous.

DIAMONDS AT THE PARIS EXHIBITION.

Scarcely on any other occasion have so many diamonds been collected and exhibited as at the Paris Exhibition; although there is always a fine show of diamond ornaments in the jewellers' shops on the boulevards, in the Palais Royal, and other quarters of Paris. But the Exhibition has brought together a more than ordinary display from Paris, Belgium, and Holland, as well as the rich products of South Africa. In the French Jewellery Gallery, Class 37, there are more than two dozen exhibitors of diamond ornaments of every kind and shape, as coronets or diadems, necklets, bracelets, sprays, earrings, rings, pins and combs for the hair, brooches, medallions and miniature frames, bouquet holders and handles for fans, breast-plates or bodices, epaulettes, and lace-work for corsages, robes, &c.; as well diamonds in the rough, as polished and set in all sorts of forms.

In the French Jewellery Court is also exposed the grand prize of the *tombola*, or lottery, a parure of diamonds valued at £8,000. This consists of a coronet or diadem, bracelet, brooch, earrings, spray, fan, &c. The lottery, consisting of one franc tickets, is to be drawn on October 30.

The diamonds shown in the Exhibition must be at least of the value of seven or eight millions sterling. There are many specialties and *tours de force*, such as a model of the Eiffel Tower, made entirely of diamonds, $3\frac{1}{4}$ feet high, which is going off to America. The Imperial diamond, belonging to a syndicate of London merchants, which weighed in the rough 457 carats, and now, cut and polished, is 180 carats. This stone is believed to have been obtained surreptitiously from one of the South African mines, and is expected to sell for about £40,000. The Koh-i-noor only weighs $103\frac{1}{2}$ carats, but there are brilliants shown more than double that size. To Bruges is attributed the credit in the 15th century of first polishing the diamond with its own dust. The troubles of the 16th century, however, drove most of the experienced workmen to Amsterdam; but Belgium has now regained its old prestige for diamond working. To Antwerp belongs the honour of improving the cleavage and polishing of these precious stones, which have increased considerably the brilliancy of the diamond by adding to its fire and lustre from the regularity of the facets. In order not to waste any of the material, the lapidary now shapes the gem according to its natural form, hence it is rounded gracefully, which adds considerably to its value. Since 1830 the cutting of rose diamonds has become a specialty of Antwerp. The fine jewels shown in the Belgian section are marvels of workmanship, and the admiration of all connoisseurs. Nearly all the Cape diamonds are now sent to Antwerp to be cut and polished. Since 1840, when the first steam diamond cutting firm was established in Antwerp by Messrs. Bovie, the industry has made rapid progress, there being now about 50 workshops, employing 3,500 operatives, and a skilled workman, according to the work he turns out, can earn from £8 per week upwards.

In the Belgian Section, there is in a show-case a fine display of large and beautifully cut Cape diamonds by two exhibitors, Messrs. Coetermans and Mr. Latinie. There are two jewel-cases, one containing a very large brilliant, surrounded by six small stones; another with six large diamonds. There is a Cape diamond in the rough weighing 300 carats, a diamond cross cut out of a single stone, unique of its kind, two long drop diamond earrings, miniature portraits of the King and Queen of the Belgians shown under large diamonds, and a small sword cut out of a diamond. The last named three objects have been presented to the King, as Sovereign of the Congo State.

In the Exhibition grounds the public have two opportunities of seeing the rough diamonds cut and polished, an industry which has made enormous strides of late years, keeping pace with the increased supply of stones from the extraordinary discoveries in South Africa.

Messrs. Boas and Co., of Amsterdam, have a small pavilion situated near the British Commission offices, where there are diamonds in cases round the room, valued at more than a million sterling. Here will be found Dutch Jews cutting and polishing, for these men are very expert workmen, and have had long experience in the business. The rough stone is set in a kind of metal solder, and is submitted to the tedious grinding process to form tables and facets, the side of the stone being changed from time to time.

The General Diamond Mining Company, of South Africa, has a very large building in the grounds, devoted to showing all the operations of washing the blue diamondiferous earth imported, and shaping diamonds. There are also models exhibited of the Bultfontein mine, of the hauling gear of De Beer's mine, maps, photographs, and a large show of diamonds worth at least a million sterling. One in the rough, an octohedron, weighs 306 carats; another polished, the largest brilliant in the world, weighing $228\frac{1}{2}$ carats, is valued at £100,000. The Shah of Persia bought here three large diamonds. Here are to be seen French workpeople employed by M. Roullina, cutting and polishing diamonds, and the tedious process of drilling diamonds, for it takes three weeks to pierce a hole the size of a pin in diameter, by a steel tool revolving 14,000 times in a minute.

There is little doubt that the earliest known diamonds came from India. Indeed, until quite modern times, no other sources of supply was known. To-day, the only Indian mines regularly worked are the northern ones at Punnah, in Bundelcund, and those in the Madras Presidency. The total yield of these is of trifling importance to the world's traffic, the bulk of the production being disposed of in the local markets, the principal of which is Benares.

It is estimated that the annual weight of Indian diamonds exported to Europe does not exceed 100 carats. They are chiefly interesting through those historical associations, nearly all the celebrated crown jewels of Europe having been derived from India. The opening of the Brazilian mines at the beginning of the last century practically closed the mines of the Deccan. The value of a diamond depends on the purity of its colour, its freedom from flaws and spots and its relative size.

The discovery of the South African diamond mines about twenty years ago created a complete revolution in the trade. The finding of the famous "Star of South Africa," a stone weighing 83½ carats in the rough, caused a great rush to the district, and the banks of the Vaal River were found rich in diamonds. This large brilliant when cut weighed 46½ carats, and now figures amongst the jewels of the Countess of Dudley; but this has been far exceeded by subsequent finds. The river diggings were soon abandoned for the farms of Du Toit's Pan, Bultfontein, and the locality where now stands the town of Kimberley; a circle of about 3½ miles in diameter indeed encloses the four principal diamond mines which have been worked to such advantage. The depth to which these principal mines have now been excavated is from 400 to 500 feet.

In an account published in the Cape Colony four years ago it was estimated that the yield of diamonds at the Kimberley mine, from the opening in 1871 to the end of 1885, was about 17½ million carats, equal to 3½ tons of precious stones, of the value of £26,000,000, and the total weight of reef and ground excavated exceeded 20,000,000 tons.

The gross value of the diamonds produced by the De Beers mine in the same period was about £9,000,000 sterling, representing about 1½ tons weight of precious stones.

The stringent police laws established have enabled a tolerably accurate idea to be formed lately of the production and sale price of the diamonds, and the following are official statistics of the yield of the four principal mines, from September, 1882, to the end of 1888:—

	Carats.	Sale Value.
Kimberley	6,050,490⅝	5,960,898
De Beers	4,444,421½	4,385,782
Du Toit's Pan..	3,651,961⅛	5,060,341
Bultfontein	3,771,981	3,765,074
Total..	17,918,854¼	£19,172,095

These totals do not include the production of some of the secondary mines as Jagersfontein, Coffeefontein, and the alluvial washings of the Vaal River, &c., which may be valued at 150,000 to 300,000 carats yearly; nor the diamonds stolen, which are estimated at one-fourth to one-fifth of all found. If we add to the above the quantity obtained previous to 1882, the entire production in the 18 years certainly exceeds 40,000,000 carats, or more than eight tons of diamonds, representing a value of at least £56,000,000 sterling.

This large production of diamonds has necessarily had an effect in depreciating prices, and there have been considerable fluctuations from time to time, but by a combination of the several mining interests into the De Beers Consolidated Mining Company, Limited, with a capital of £12,000,000 sterling, the production will in future be limited to 2,000,000 or 2,500,000 carats per annum, a quantity sufficient to meet the current demand, and at which prices will be maintained.

In 1881 and 1882 the average price of Cape diamonds was—for those of Du Toits Pan 45s. a carat, for Bultfontein 32s., and those of the Kimberley and De Beer's mines about 30s. The over-production led to a fall of 40 to 50 per cent.

The current prices in August, 1885, were—for those of Kimberley 15s. 4½d. per carat, De Beers 15s. 11d., Du Toits Pan 23s. 10¾d., and Bultfontein 16s. 8¾d. Since then prices have recovered, Du Toits Pan to 40s., Bultfontein to 30s., Kimberley and De Beers to 28s. per carat.

The public have a general impression that the Cape diamonds are usually of a yellow tinge, but this is not so, and they may convince themselves to the contrary by inspecting the large collection of diamonds shown in the South African pavilion. There are stones, it is true, of various shades of yellow, and the deep orange tint is highly valued by collectors for its rarity. The Cape diamonds, as a rule, are indeed less coloured on the average than those of India and Brazil. This erroneous opinion arises from the fact that the largest Cape diamonds found are somewhat yellow, while the large diamonds of India and Brazil are of a white and brilliant hue. The diamonds obtained from the mine of Jagersfontein, in the Orange Free State, are remarkable for their whiteness, verging to blue.

COMMERCIAL EDUCATION IN FLORENCE.

Sir Dominic E. Colnaghi, Consul-General at Florence, gives at the commencement of his report on the industries of the Province of Florence, an account of the general system of education in the Province of Florence, with special refererence to elementary and professional instruction.

Education in Italy is classed in three main divisions: — 1. Primary or elementary. 2. Secondary, classical and technical. 3. Superior, which includes the universities, the Istituto dei Studj Superiori of Florence, the schools of application, &c.

The following remarks refer to the commercial schools:—

"*Scuola di Commercio Maschile* (Male School of Commerce), Florence, was founded by the municipality in 1876. It is placed under the immediate authority of the Syndic, and is subsidised by the Ministries of Agriculture, Industry and Commerce,

and of Public Instruction, and by the Florentine Chamber of Commerce. Youths are admitted at 15 years of age, and the course of instruction, spread over two years, includes :—First year, Italian literature, English and French languages, commercial geography, civil rights and duties, social economy, applied mathematics, book-keeping, commercial technology ('merciologia'), and writing; second year, the above subjects are further developed, with the addition of the history of commerce. The annual fee charged is 40 lire.

"*Scuola Tecnica e Commerciale Femminile* (Female Technical and Commercial School), Florence.—The object of this school is to supply a want largely felt in the education of girls of the middle class. Founded in 1879, as a purely commercial school, it is now divided into two branches—technical and commercial. The course of instruction, which extends over two years, includes, in both divisions, Italian, French, history, geography, arithmetic, rights and duties, book-keeping ('contabilità'), and writing. In the technical divisions, in addition, mathematics, natural sciences, and drawing; in the commercial, commercial technology, political economy, commercial law, and English are taught."

The Consul-General then proceeds to describe the Professional and Art Industrial Schools, as those of the decorative industrial arts, and of design, and the school of arts and trades, school for weaving and dyeing, &c.

APPARATUS FOR PROVIDING A STEADY, PLATFORM FOR GUNS, SEARCHLIGHTS, TELESCOPES, &c.

In a paper read before the Mechanical Section of the British Association, Mr. Beauchamp Tower describes an apparatus large enough to carry a 3-pounder gun, which he has constructed and mounted on a 25-ton steam-yacht, and which keeps perfectly steady, even when the vessel is rolling and pitching violently.

The apparatus consists of the platform, which is the part to be kept steady, and which is hung in gymbals. The steadying forces are applied by four cylinders attached to the platform, which push by means of rams at four external points. The action of these cylinders is controlled by a wheel revolving rapidly in a horizontal plane on a ball-and-socket bearing attached to and between the four cylinders. Water at 100 lbs. pressure is pumped by a pumping engine through the gymbals, which are made hollow for the purpose, and thence through a pipe on the platform to the ball-and-socket bearing of the wheel, which has a passage through it for the water to pass to a cavity in the centre of the wheel; from this cavity some of the water passes to tangential jets, which cause the wheel to revolve by their reaction at about 1,500 revolutions per minute. The remainder of the water issues from an axial jet which projects upwards from the wheel, and has opposite to it, and at a distance equal to about the jet's diameter, four ports grouped close together, and each connected by a passage to one of the four cylinders.

The wheel, being hung a small distance above its centre of gravity, settles itself down to revolve in a truly horizontal plane, and to throw a truly vertical jet out of the axial jet-nozzle. This jet striking on the four ports causes a water-pressure in the four cylinders, which pressure is equal in all the cylinders if the jet is truly concentric with the four ports; but, if it is not, one of the ports receives more of the jet than the others, and the cylinder connected to it has a greater pressure, and, consequently, pushes harder than the others, and pushes the platform over till the ports and axial jet are concentric. The object and advantage of this arrangement is, that while the wheel acts powerfully on the platform it suffers no reaction on itself, and no matter what disturbing forces are brought to bear on the platform none of them can affect the wheel.

The wheel, revolving in a horizontal plane, and hung a short distance above its centre of gravity, is in reality a long-period conical pendulum having a period of about 90 seconds, and is analogous to Mr. Froude's wheel which he used for recording the rolling of ships. This was a pendulum whose period was longer than that of the waves, so that it might be undisturbed by the wave forces. The author has experimented with this apparatus at sea for a considerable time, and has overcome the usual practical difficulties and brought the apparatus to a high state of perfection.

The apparatus is also applicable for controlling swinging-cabins, and experience with it seems to justify the belief that the abolition of the angular movement alone would prove a great mitigation of sea-sickness.

CONDENSED FRUITS AND VEGETABLES.

The introduction of preserved or condensed foods, both of animal and vegetable origin, in hermetically sealed tins, has developed to an enormous extent of late years. One of the most successful of the recent introductions is undoubtedly the pine-apples that are imported from Singapore. Many persons who have an objection to tinned foods generally, have pronounced these to be of excellent quality and flavour, and though they are to be obtained almost at any grocers, and at a very cheap rate, they are not in such great demand as might be expected. The prejudice against new products or preparations is difficult to overcome, and this prejudice is more general even amongst the poorer and working classes than amongst those better informed. There is a general belief amongst them that only the commoner qualities of food products are put up into tins, and, consequently, they reject them. The success of the pine-apple, however, treated thus ought to dispel that notion, and to lead to other fruits, especially those of tropical countries, to be similarly treated for

export purposes. There seems to be no reason why mangoes, guavas, rose-apples, and a host of others should not become regular articles of import and consumption, and even, perhaps, some of the other vegetable productions of distant lands. That the ordinary English vegetables and fruits can be preserved for winter use when the fresh ones are not obtainable has been proved over and over again.

The preservation of vegetables and herbs by desiccation by the natural action of the sun has been known to and practised by agriculturists from time immemorial. Within historical times it has been supplemented and improved upon by the introduction of drying in kilns. Both the ancient Chinese and Egyptians used this method in remote ages. The vegetable substances offered great difficulty for stowage and transport in consequence of their bulk, and to the imperfect nature of their preservation. This difficulty was very successfully overcome in 1846 by a M. Masson, who was head gardener to Louis Philippe, King of the French, and who invented a process by which kiln-dried vegetables herbs and fruits can be compressed by powerful hydraulic pressure, retaining their hygienic properties for a length of time. By this process a quantity of vegetables sufficient for a mess of 40,000 persons was reduced to the volume of one cubic metre (one yard and three inches cubic), thus effecting an enormous saving in stowage and in transport.

Later on, the invention was patented by Messrs. Chollett and Co., of Paris and London, who introduced improvements, and have ultimately brought the process to its present state of perfection, so that their successors, Messrs. C. Prevet and Co., prepare enormous quantities of dried and compressed vegetables and fruits for the supply of the British army and navy, the Board of Trade making it compulsory that every outgoing vessel is supplied with a certain quantity.

At the time of the Crimean war these prepared vegetables were very largely used, and were mixed, dried, and compressed under certain rules laid down by an International Anglo-French Military and Naval Medical Commission, to which the celebrated Alexis Soyer, who was Chief Inspector of Army Cookery to the campaign, gave practical assistance. For the mixed vegetables, the following proportions were decided upon, and are still adhered to :—

	Per Cent.
Potato	40
Carrot	30
Cabbage	10
Turnip	10
Seasoning herbs (onion, leek, celery, parsley, parsnip, &c.)	10
	100

The vegetables are gathered in the autumn, when they are in their prime, and carefully sorted, then cleaned, washed, peeled, sliced, and slightly steamed (fixing the saccharine and albuminous parts, preventing to a great extent the volatilisation of the essential oils, and thus preserving their hygienic and anti-scorbutic properties). The various manipulations were formerly performed by hand, but all are now done by machinery. The vegetables thus prepared are then dried in kilns and on lattice-work trays by currents of moderately hot dry air, thereby retaining their natural colour, flavour, and aroma. This stage of the process requires the greatest care and attention, so as to keep the temperature constantly at the level as ascertained by experience to be necessary for each kind of vegetable. The vegetables and herbs are then carefully mixed in the proportions given above, and then compressed to one-eighth of their original bulk (when fresh) by powerful hydraulic pressure into moulds, thus forming square slabs about three-quarters of an inch thick, grooved so as to be divided into cakes of five rations each, at the rate of one ounce per ration, easily separated for convenience of issue. These slabs are then wrapped in paper, and packed by machinery into square tins, which are hermetically soldered. Before the lid is soldered down, a punch stamps it automatically, from the inside, with the season of manufacture. When two years appear on this stamp, as "1888-89," the first is the year of the crop, and the second the year of compression. The tins are now made of bright "coke" tin-plate of the best quality, it having been found by experience that the vegetables keep much better in this material than in the dull terne-plate formerly used.

The vegetables and herbs are also prepared separrately, as there is a great demand in some quarters for some kinds than for others, as, for instance, in South Africa for compressed celery as a cure, when stewed, for rheumatism caused by sleeping on the open veldt. In India, for compressed onions, to make a soup considered a sovereign remedy for the effects of over indulgence in spirituous liquors. In the Hudson's Bay Territory for the same article as a generator of warmth in the stomach; and in Burmah for compressed apples and pears, which are prepared in a similar manner to the vegetables and herbs. All these vegetables, herbs, and fruits are also obtainable in their dried and dessicated condition, without being compressed into cakes. In either state they are extremely convenient, portable, and useful, as are also the prepared and condensed soups and flours made from potato, pea, lentil, haricot bean, carrot, chestnut, &c. They are, moreover, wholesome, and the use of these vegetables, fruits, &c., will probably become more widely extended.

SAFFRON TRADE OF VALENCIA.

The average yield of the saffron crop in Spain amounts to between 180,000 and 225,000 pounds, quantity four-fifths of which is quite sufficient to cover the entire consumption of Spanish saffron, so

that in seasons of an abundant crop, when, perhaps, says Consul Mertens, 280,000 to 300,000 pounds are harvested, a heavy stock accumulates. Three successive abundant crops generally cause the farmers to reduce their plantations. The lowest price at which saffron growing can be made to pay closely approaches the equivalent of about 29s. a pound. At Pithiviers, in the Gâtinais, France, a maximum crop of from 27,000 to 34,000 pounds was harvested in former years, but since the severe frost which occurred in that district in 1879, the largest crop has not exceeded 11,000 pounds; in 1887 it was only about 7,800 pounds; and in 1888 scarcely reaching 2,000. At present, Spanish saffron is said to unquestionably rule the market. The average Italian crop is placed at 11,000 to 14,000 pounds per annum; and in Austria saffron growing only pays if the price is at least 54s. a pound. The Austrian saffron is considered to be the best of all, and next to it ranks the Gâtinais, the only drawback of which is that it very quickly loses its vivid colour. In Spain, saffron is divided into five grades, each cultivated in a different district. The centre of the export trade is Valencia, where the saffron is stored by the merchants, who generally advance money on it to the cultivators. These merchants sell it to the local agents of foreign houses, who export the drug in strong wooden cases, with an outer covering of matting, each case about 160lbs. in weight, in which the saffron is packed in white paper. For export to distant countries, however, the saffron is generally packed in tins which are placed in wooden cases. The principal buyers of Spanish saffron are a few firms in Southern Germany. Pithiviers and Marseilles used to buy large quantities in Spain, but do not now take quantities of any importance. Other countries purchasing direct from Spain are England, North America, South America (especially Buenos Aires, Montevideo, and certain ports on the west coast), British India, and Japan. Aduldreation is, says Consul Mertens, practised to a very large extent. At Novelda, in the province of Alicante, saffron is said to be largely adulterated.

Notes on Books.

The Popular Beverages of Various Countries, natural and artificial, fermented, distilled, aerated, and infused, their history, production, and consumption. By P. L. Simmonds. London: J. Gilbert Smith.

Mr. Simmonds commences with an account of ales, beers, and porter, and ends with a chapter on casks and cask-making. Wines, from champagne to elder wine, occupy much space. In a table of the comparative annual consumption of wine per head in various countries, Italy stands at the head with 20 gallons, and the United Kingdom near the bottom with ·36 of a gallon. Sweden is at the actual bottom with ·20. Distilled beverages are fully treated on as well as liqueurs, cordials, and bitters. The chapter on infused beverages contains much information about tea and coffee, and their various substitutes. While the consumption of tea has largely increased in the United Kingdom, that of coffee has decreased, and this may be partly accounted for by the large sale of chicory. The inhabitants of the United States are the largest consumers of coffee in the world, and their consumption averages 11 pounds per head of the population. Belgium and Holland come next with 10 lbs. per head each, then Norway and Denmark with 9 lbs. per head each, Sweden and Switzerland with 7 lbs. per head each, Germany with 5 lbs. per head, and France with 4 lbs. per head. The United Kingdom averages 0·86 lb. per head, and European Russia is the lowest of all with 0·10 lb. per head. Besides the ordinary drinks, Mr. Simmonds has collected information relating to a large number of curious beverages drunk in corners of the earth, and water itself and the various aerated waters are not overlooked.

Grammar of the French Language of Business, with Reading Lessons and Exercises, being an Introduction to Mercantile Correspondence. Edited from the German of Dr. Rudolf Thum, with additions by Edward E. Whitfield. London: Hachette and Co.

Concise French Commercial Reader, being a sequel to Grammar of the French Language of Business, by Edward E. Whitfield. London: Hachette and Co.

The object of this grammar is to give to commercial students the particular information they require, and all the French sentences for translation, and the exercises in composition are drawn from correspondence or market reports, and in the rules regard is specially paid to office work. Each chapter is composed of four parts. (1) The grammatical rules, (2) a reading lesson with literal English version, (3) notes appended to each lesson, and (4) exercises for translation into French.

The Reader forms a complement to the grammar, and the extracts given refer to the main topics of commercial education.

Notes on Water Supply in New Countries. By T. W. Stone. London: E. and F. N. Spon.

The author deals with his subject under the three main heads of (1) Inception, (2) Design and Construction, (3) Cost. Under the first heading the questions that arise are many. There are rainfall, discharge of rivers or streams, per-centage of rain flowing to rivers or streams, loss from evaporation and percolation. Each of these points are discussed, and the work is illustrated by a series of eighteen plates.

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All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

ART WORKMANSHIP PRIZES.

The judges appointed by the Council of the Society of Arts have awarded the following prizes for objects at the Second Exhibition of the Arts and Crafts Exhibition Society, the New Gallery, Regent-street :—

METAL WORK.

To F. Taylor, £5 and bronze medal. Pair of candle brackets in wrought iron. (493)

To T. R. Spence, A. J. Shirley, and G. Neale, £5 and medal. Sign in wrought iron. (852)

To John Pearson, £5 and medal. Group of brass and copper *repoussé* plates. (64)

To J. Williams and R. Underhill, £3. Coal scuttle in *repoussé* and wrought copper. (214)

To A. Trowbridge and A. Halliday, £2. Electrolier. (839, 860)

To F. W. Troup, £2. Copper wire chain. (598)

POTTERY.

To Edith D. Lupton, £3. Doulton bowl. (837)

To Mark V. Marshall, £3. Stone ware jug. (553) Vase. (594^4)

To Horace Elliott, David and Edward Jenkins, £2. Oriental vase. (806^3)

To J. S. Dewdney, £2. Renaissance vase. (515)

To Walter and Jessie Gandy, £2. Jar, salt glazed. (594^8)

To W. L. Brown and J. A. Bamkin, £2. Two vases. ($594^{16, 17}$)

To Charles Passenger, £2. (448)

To F. Passenger, £2. (448)

To H. Bale, £2. (310)

ENAMELS.

To Rosa Wallis, £3. Enamel in manner of old Limoges. (335)

GLASS.

To Edward John Hillebauer, £2. Engraved glass. (835)

JEWELLERY.

To William Smith, £2. Specimens of gold and silver work. (603^3)

GESSO.

To William Palmer, £3. For Gesso decoration for wall. (536)

WOOD-CARVING AND CABINET WORK.

To William S. Williamson, £5 and medal. Frieze in carved yellow pine. (513)

To George Turner, H. Green, W. Thatcher, and A. Dicks, £5 and medal. Inlaid cabinet (Morris and Co.) (412)

To W. Thurtell, £5 and medal. Panel of door of small cabinet, rosewood inlaid with ivory. (276)

To Thomas Jacob, £3. Table top, inlaid. (777)

BOOKBINDING.

To R. de Coverly and F. Harvey, £2 each. Todten Tanz zu Basel. Stained calf. (106) Moore's Epicurean. Green morocco. (106)

To Arthur Alaric de Coverly, £2. Stevenson's Underwoods. Morocco. (106)

TEXTILES.

To Flora E. J. Hayman, £3. Piano cover. (285)

To Louisa E. Macpherson, £3. Two portières. (326)

To S. Hare, £3. Couvrette of silk. (336)

To Mrs. Gerald Davies, £3. Bed cover. (123)

To C. Gilbert, £3. Screen panel.

To Ethel King Martyn, £2. Portière panel. (327)

To Mrs. C. J. Staniland, £2. Panel of muslin worked in embroidery silk. (125)

LACE.

To Presentation Convent, Youghal, £3 and medal.
To Bath and Shelley School, £3 and medal.
To Carmelite Convent, New Ross, £3 and medal.
To Society of Poor Clares, £2.

Awarded to the designers and workers of the lace.

To Mary E. Fox, £2. Specimen of insertion and wristbands. (140)

DESIGNS.

To T. W. Bladen, £5 and bronze medal. For design in chalk for church decoration : "Isaiah." (49)

To T. Erat Harrison, £3. Book plates. (642)

To Dora M. Stewart, £2. Designs for printing on cotton or silk. (383, 384) Design for printing on cotton. (400)

To Henry Webley Beavan, £2. Design for ceiling paper. (386)

To Lily M. Betts, £2. Design for ceiling paper. (146)

To A. Willcock, £2. Design for cretonne. (47, 48)

To John Rigby, £2. Design for machine printed Indian muslin curtains. (147)

To Rowland Jones, £2. Designs for cloth book cover and for painted glass.

Proceedings of the Society.

CANTOR LECTURES.

INSTRUMENTS FOR MEASURING RADIANT HEAT.

By C. V. Boys, A.R.S.M., F.R.S.

Lecture IV.—Delivered April 15th, 1889.

In any of the combinations of thermopile and galvanometer described in the last lecture the immediate effect of a current is the production of a twisting force or moment between the coils and needle, which produces a deflection in the moveable part of the apparatus, that is, in the needle. If the needle were fixed, and the galvanometer coil moveable, then the coil would be turned with the same force as before, but such a construction of apparatus would be impracticable. Supposing, however, an instrument with a fixed needle and a moveable coil to be made, the deflecting force would be simply proportional to the strength of the magnetic needle, and therefore if, instead of a small needle, a powerful horse-shoe magnet were made use of, then just as the magnetic field in which the coil lies, due to the strong magnet, is stronger than the corresponding field due to the needle, so in the same proportion would the coil be more powerfully deflected for any current by the magnet than it would by the needle. The advantage of the increased field thus available is so enormous that the coil may be to a great extent reduced in size and complexity, and still leave a balance in favour of the combination of magnet and moveable coil.

This was first effected in 1836 by Sturgeon, to whose researches in this direction Professor S. P. Thompson has directed my attention. They are published with his other work in a thick quarto volume.*

Sturgeon used a variety of pairs of metals, which he generally combined by soldering to the extremities of a semicircular piece of wire made of one metal the ends of a straight piece made of the other metal. He then suspended these frames in front of one pole of a strong magnet, and heated one junction. The frames were deflected one way or the other, according to the junction that was heated or the pole of the magnet that was employed. I have made one of Sturgeon's frames, modified in detail only, in conformity with our modern knowledge, and I shall be able to show that this very simple contrivance is capable of showing very small effects of heat. It consists simply of a rectangular frame, of which the upper side and the two ends are made of copper wire, while the lower side is composed of two bars made of the alloys described in the last lecture, soldered end to end. A needle point is soldered to the middle of the upper side, which rests upon a piece of glass, so as to allow the frame to turn freely. The two poles of a strong horse-shoe magnet are thrust through the open frame without touching it anywhere, and an index of straw moving over a scale shows the deflection of the frame, and the direction in which it moves. A small piece of iron wire attached to the frame serves to bring it to the zero of the scale. If now a lighted match is held opposite to the centre of the compound bar, the frame almost immediately begins to move in one direction, while if heat is applied to the ends of the compound bar, it instantly swings round and is deflected in the opposite direction. I may perhaps here remark that Sturgeon found that a coil suspended in a magnetic field made a most delicate galvanometer.

M. D'Arsenval has invented an instrument on this principle, which he showed at a meeting of the Physical Society of France, on February 5th, 1886. It consists simply of a pair of wires, one of silver, and the other of palladium, soldered together at their extremities, and forming a rectangular frame, with the junctions in the middle of the upper and lower sides. The frame is suspended by a single fibre of silk between the poles of a horse-shoe magnet, and is directed by a fragment of iron wire attached to it. He has made the frame of two different forms, either short and wide, in which case he places within it a fixed cylinder of soft iron, to increase the strength of the field in which the circuit hangs, or else very long and narrow when there is no room for an iron core; but in this case the legs of the magnet can be made so close together as to attain the same object. The deflection is read by means of a mirror in the usual way, but in this instrument the mirror serves a double purpose, screening, in addition, one of the junctions over which it is fixed from the influence of any radiation that might fall upon it as well as upon the other junction, but this is a point to which I must refer later.

* "Scientific Researches, experimental and theoretical, in Electricity, Magnetism, Galvanism, Electro-Magnetism, and Electro-Chemistry," by William Sturgeon.

M. D'Arsenval has found that the instrument is very sensitive, and in the case of the long and narrow frame, that it is also exceedingly rapid in its movements and dead beat.

About a year after M. D'Arsenval had published an account of his instrument, I heard of the results obtained by Langley with his bolometer, an instrument which, in his hands, became far more delicate than the ordinary thermopile. I felt that it was very unfair to the thermopile to compare it in its ordinary form, as made thirty years ago, with Prof. Langley's instrument, in the development of which all the knowledge and resources of the present day have been made use of. Owing to the very high electromotive force set up at a thermo-electric junction, and the very small temperature co-efficient of resistance of conductors, on which the bolometer depends, I fancied that if an instrument depending on thermo-electromotive force were designed and carried out as well as the bolometer had been, that perhaps a still more delicate and satisfactory instrument might be the result. It was in trying to solve this problem that I devised an instrument the same as Sturgeon's and M. D'Arsenval's in principle. Had I been aware that M. D'Arsenval had designed an instrument of the kind, I should almost certainly have thought no more about it. It is perhaps well that I was ignorant of the work of this distinguished *savant*, for not only have I developed the theory of instruments of this class to a considerable extent, but I have made an instrument which I am sure is far more sensitive than his, and which at the same time must be less affected by numerous disturbing causes than any other instrument for measuring radiant heat that has been made, and, in addition to this, it was the difficulties that I met with in trying to find a suitable suspending fibre that led to the process for making fine fibres of quartz.

In my instrument, which, at General Donnelly's suggestion, I called a radio-micrometer, a circuit is suspended in a magnetic field. The circuit is composed of three metals, as follows:—There are, in the first place, two very small bars of antimony and bismuth, or, preferably, of the alloys to which I have so often referred, which are soldered side by side at their lower ends to the side of a small disc, or, for spectrum work, to the end of a narrow strip of copper foil, on which the radiation is to fall, as in Lord Rosse's thermo-junction, while their upper ends are soldered to the ends of a long, narrow ∩-shaped piece of copper-wire, which completes the circuit. The upper end of the copper stirrup has soldered to it a small piece of straight wire, which is cemented into the end of a very fine glass tube. At the upper end of the glass tube is fixed a small plain mirror, and the whole is suspended by a fine quartz fibre in a narrow hole in a mass of brass, or better of copper, between the pole pieces of a powerful magnet.

I have investigated* the theory of this instrument with the view of obtaining the best possible result. The main conclusions are, I think, of sufficient interest to bring before your notice.

In the first place, it follows, for reasons similar to those advanced in the discussion of the thermopile and galvanometer, that the dimensions of the moving system should be as small as it can be made, provided that whatever size it is made the several parts are properly proportioned. The limit of smallness is practically determined by the bars of antimony and bismuth, or of alloy, because of the difficulty of making and soldering such materials when excessively thin. I find by experience that I have no difficulty in making these bars far finer than any which at first I expected it would be possible to handle, and in soldering them at each end, and even, if necessary, taking a circuit to pieces, cleaning off the solder and re-soldering, when they are no more than one-two-hundredth of an inch thick, and one-fiftieth of an inch wide, that is so fine that thirty of them could be packed in the space occupied by a single bar, such as is used in an ordinary thermo-electric pile of eighty pairs.

Now, whatever size is given to the bars, it is clear that for any size of bars there is some thickness of copper wire which is most suitable, for if it is made very thin indeed, the conductivity of the suspended system will be reduced in a higher ratio than the moment of inertia; on the other hand, if very thick, the moment of inertia will be increased in a higher ratio than the conductivity. But, what is not immediately evident, is that no matter what shape or size, or number of turns may be given to the copper wire, one particular thickness is better than any other. This is given by the relation—

$$a = \frac{1}{b} \sqrt{\frac{K v}{C u}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Where $a =$ the sectional area of the copper wire.
$b =$ the breadth of the circuit (assumed small compared with the length).

* "Phil. Trans." Vol. 180, 1889, p. 159.

Where u = the moment of inertia of a unit piece of copper (1 × ·1 × ·01 cm.) at 5 mm. from the axis.

v = the resistance of a unit piece of copper.

K = the moment of inertia of the bars, mirror, and connecting tube.

C = the resistance of the bars.

There must also be some size of circuit which will give the best result, that is the greatest deflection in a given field, and with a given period of oscillation, for if made very large or very small, more is lost than gained. The best area for the circuit to enclose is given by the equation—

$$A = lb = \tfrac{1}{2}\sqrt{\frac{KC}{uv}} \quad . \; . \; . \; . \; . \; . \quad (2)$$

Where the symbols have the meanings already given, and in addition—

A = the area enclosed by circuit.

l = the length of circuit.

In all cases one turn of copper wire is better than any greater number. It does not matter how l and b are modified so long as b is kept small compared with l, and so long as their product is not allowed to change. Under these conditions the area enclosed by the circuit, the moment of inertia, and the resistance of the circuit all remain the same, and therefore the sensibility is not affected.

When a and A have the values given by the two equations above, the following very simple relation will be found to hold. The resistance of the copper part of the circuit is equal to the resistance of the bars and the moment of inertia of this copper is equal to the moment of inertia of the bars, the mirror, and the connecting stem. Further, what I have called the efficacy of the combinations, that is the sensibility in a unit magnetic field, is—

$$E = \tfrac{1}{8}\frac{1}{\sqrt{(KCuv)}} \quad . \; . \; . \; . \; . \; . \; . \quad (3)$$

Though this is the circuit which will give the greatest deflection in any field when mounted so as to have any given period, it does not follow that it will be the most convenient one to use in a very strong field. The force tending to move the circuit, and the ultimate deflection, is proportional to the strength of the field, but the resistance to the motion due to the reaction between the field and the current induced by the motion is, for any speed, proportional to the square of the strength of the field; and so, though with weak fields the circuit may move readily enough, this is not the case when the field is strong, even though the force urging it to move is greater. I can show the effect of this "damping" by a simple experiment. There is suspended between the poles of a magnet a circuit made of copper only, and the strength of the field in which it hangs may be varied by moving the pole pieces of the magnet. At present the field hardly exists, and so the copper circuit is able to oscillate freely, and in consequence to make many swings before it comes to rest. On increasing the strength of the field, it is evident that the circuit is not so free as before, because any swing is only a small fraction of the one before it, and after four or five oscillations it ceases to move. On further increasing the strength of the field, the oscillations fall in amplitude at a still higher rate, and they seem each to take very little longer, but there are fewer of them before the visible movement comes to an end; at last the resistance to the motion become so great that the circuit when displaced moves up to its position of rest, and is unable to pass beyond, but now it takes an appreciably longer time to make the half swing than it did before. On still further increasing the field, the resistance becomes so great that the circuit is hardly able to move at all, but very slowly creeps along, and may take ten, or perhaps a hundred times as long to come to its resting place as it did in the last case.

The question that then arises is what is the most suitable field to employ; if it is weak, the circuit will oscillate so freely that owing to the number of swings it may take a long time to come to rest, and further, the deflection will not be great. If the field is as strong as it can be made the circuit may meet with so much resistance to its motion that it will take an enormous time to come to rest, though it is true the deflection, when it can be read, will be much greater. It will make it easier to come to a just conclusion, if I state in a few cases to what extent the period of oscillation is increased when the resistance to the motion is sufficient to produce certain definite decrements in the amplitude of the oscillation.

	Ratio of any Oscillation to the one before.	Period of Oscillation.
Undamped	1	...... 1·00
	$\frac{1}{2}$	...... 1·02
	$\frac{1}{5}$	...... 1·12
	$\frac{1}{10}$	...... 1·24
	$\frac{1}{100}$	...... 1·77
	$\frac{1}{200}$	...... 1·96

	Ratio of any Oscillation to the one before.	Period of Oscillation.
Undamped	$\frac{1}{1000}$	2·42
	$\frac{1}{10000}$	3·10
	$\frac{1}{100000}$	3·80
	$\frac{1}{1000000}$	4·51
Dead beat	$\frac{1}{\infty}$	∞

Now the strength of the field should be so chosen that the resistance to the motion of the circuit caused by it is not quite sufficient to make the motion perfectly dead beat. Supposing that it is possible to observe a deflection accurately to, say, one-thousandth of the whole, it is not only useless to make the decrement less than $\frac{1}{1000}$, but harm will be done because of the rapidity with which the time of coming to rest is increased when the magnetic field is made stronger. On the whole, I think it is preferable to have the decrement such that the elongation of the first swing beyond the position of rest is just distinguishable as an elongation, for then it is possible to make a definite reading in a very short time, a matter of importance when experiments are being carried on under variable conditions.

However, it is a matter of little consequence whether the ratio of damping is very small, or whether the motion is just dead heat, what is really important is that the resistance shall not be more than sufficient to make the motion dead beat. If, for instance, the field that is just sufficient for the dead beat conditions is doubled in strength, then though the ultimate deflection obtainable may be also doubled, the velocity of motion will be halved, and it will take four times as long for the circuit to apparently come to rest.

Now when anything, as is the case here, is subject to a force proportional to the displacement, and to a resistance proportional to the velocity, the motion will be just dead beat when half the resistance at unit velocity is equal to the square root of the controlling force at unit displacement. It may be proved that when the circuit is made of the dimensions which equations (1) and (2) show to be best, the value of the magnetic field, H, that will just make the motion dead beat is given by the equation—

$$H = 8\sqrt{\frac{\pi}{\tau}} \quad \sqrt{(u\,v)} \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

in which τ is the complete period of vibration (undamped).

Since the symbols K and C have been eliminated, this shows that, no matter what the bars are made of, or what dead weight is fastened to them, provided the copper part of the circuit is formed so as to give the greatest efficacy, the magnetic field that will just make the motion dead beat, conveniently called the dead beat magnetic field, will always be the same, and this depends simply on the properties of copper, and the period that is chosen.

It follows from equations (3) and (4) that the sensibility, S, obtained by the best circuit in the dead beat magnetic field, may be found from the relation—

$$S = \sqrt{\frac{\pi}{\tau}} \frac{1}{\sqrt{(K\,C)}} \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

which is independent of the properties of copper. It thus appears that the sensibility obtained by the above combination is not affected by the nature of the material with which the circuit is completed, so that a badly-conducting metal, or even glass, would be as good as copper. This very paradoxical result may be explained by imagining what would happen if a specimen of copper could be found with one hundred times its proper resistance. Under these circumstances, equation (1) shows that the wire would have to be made with ten times the sectional area, and equation (2) that it would be ten times as short, and thus both the resistance and the moment of inertia of the circuit would be the same whichever metal were used. Now equation (4) shows that the field would have to be ten times as strong, from which it immediately follows that the motion must still be dead beat, if it was so before, since the circuit has the same moment of inertia and the same resistance as before, but encloses one-tenth of the space in the magnetic field, which confirms equation (4), and that the sensibility must be unchanged, which confirms equation (5). Of course, practically, glass could not be used to complete the circuit, because with such bars as it is possible to make, the thickness of the glass would become enormously greater than the length of the circuit, which must, by original assumption, be large compared with the breadth, and because a magnetic field of an almost infinite strength would be necessary.

The actual strength of the dead beat magnetic field, that corresponds to the material copper and the arbitrary period 10 seconds, is almost exactly 272 C.G.S. units. Now, since it is easy to obtain a field four or five times as strong as this between the poles of a permanent magnet, it is a question whether it will be possible to use a much stronger field

with advantage, not without varying some of the other conditions, for that would cause a resistance to the motion of the circuit of from 16 to 25 times that which is necessary to make it dead beat, so that it would require from 16 to 25 times as long a time in which to come to rest, but with such a modification in the circuit as will keep the motion dead beat. The thickness of the copper wire must not be altered, but the size of circuit may be reduced as the field is increased in strength, so as to maintain the dead beat relations, and the result is a slight gain in sensibility. Calculation shows that if the field is made M times as strong as the dead beat magnetic field, the area must be made $(2M-1)$ times as small, while the sensibility of the combination will become $\left(2-\frac{1}{M}\right)$ times as great. Thus with a field four times as strong, the sensibility will be $1\frac{3}{4}$ times as great, while with an infinite field it could not be more than doubled.

The practical conclusion, then, is that if a circuit is made approximately of the best proportions, the field may be varied by sliding the pole pieces until a convenient decrement is produced, when the sensibility will not greatly differ from the greatest which it is possible to obtain.

I may mention also that the size of the mirror is a matter of some importance. If large, so as to give plenty of light, say as large as the mirror of an ordinary reflecting galvanometer, the moment of inertia would be so enormous as to completely spoil the instrument. If very small, so as to have a negligible moment of inertia, it would neither reflect enough light nor would it on optical grounds be capable of defining sufficiently well. That size is best of which the moment of inertia is about one-third that of the bars. I found that mirrors made of the thinnest microscopic cover glass, one two-hundredth of an inch thick, and about one-eighth of an inch square, silvered at the back, fulfilled these conditions in the case of the particular circuit that I have in the instrument upon the table. I have found that the definition of such a mirror, if properly made and mounted, is so good that it will produce an image of a cross wire upon a scale one metre distant, which is a sharp black line not much more than one-tenth of a millimetre wide, and which can certainly be read to this degree of accuracy. I have not found that galvanometers are usually read more accurately. It is, of course, necessary in the case of these small mirrors to employ a brighter light than a lamp flame, but, with oxygen at its present low price, there is no reason why a small limelight should not be used.

The following dimensions, which are nearly those given by the equations, I have found by experience to answer well, and to be not so small as to be too difficult to make:—Thermoelectric bars $\frac{1}{3} \times \frac{1}{50} \times \frac{1}{200}$ inch. No. 36 copper wire made into a circuit one inch long, and about $\frac{1}{10}$ inch wide, a copper heat-receiving surface, blackened on the side exposed to the radiation $\frac{1}{10}$ inch in diameter, or $\frac{1}{4} \times \frac{1}{30}$ inch. Mirror $\frac{1}{10}$ inch square, $\frac{1}{200}$ inch thick. Quartz fibre 4 inches long, $\frac{1}{6000}$ inch in diameter.

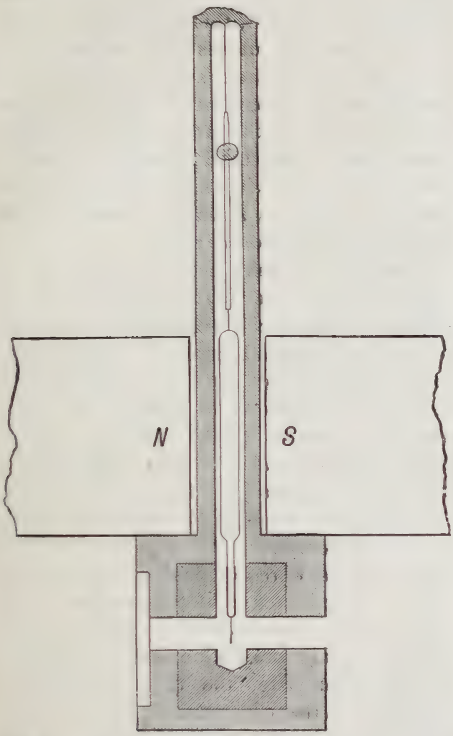
The complete circuit connecting stem and mirror, *m*, is shown in Fig. 10. One of these circuits that I made weighed less than half a grain, and though there were five soldered joints, the total weight of solder used did not exceed $\frac{1}{65}$ grain.

FIG. 10.

There is one point that I should mention. The disturbance caused by the magnetic qualities of the antimony and bismuth bars, small though they are, was so great as to make the instrument completely unusable; but this difficulty was overcome by making the centre of the block of metal in which they hang of iron, as shown by the darker shading in Fig. 11 (p. 357). This screens off the magnetism of the pole-pieces from the bars, but leaves the rest of the circuit in a strong field. The copper wire used must be carefully chosen, as much is so mag-

netic as to be useless; when a non-magnetic piece is found, it must not be cleaned with emery, or it will become evidently magnetic. I mention this to show how feeble the forces are that are used, and when I say that the instrument is perfectly free from every influence except that of radiation upon the receiving surface, it will be evident that the effects of many disturbing causes which ordinarily give so much trouble have been very completely avoided. A strong magnet may be moved about close to the instrument, but no effect whatever can be observed. Magnetic disturbances are the most fruitful source of

FIG. 11.



trouble with the ordinary galvanometer; for instance, it is not possible to do any serious work with a galvanometer in the Science Schools, South Kensington, except at night, because of the movements of an hydraulic lift, of which the ram is a huge weak magnet, presenting in its movements alternately north and south poles to every instrument on the ground floor. There are no connecting wires or binding screws, and so no uncertain thermo-currents are set up, nor induced currents due to the movement of the connecting wires through the earth's magnetic field. The sensitive part of the instrument is very small, and is enclosed in a narrow hole in a solid mass of metal, which, moreover, is protected by being enclosed in a wooden case, and so temperature changes in the room, and hot and cold draughts are not felt. The instrument is very quick in its indications, its sensibility and its decrement can be varied at will. The following figures, obtained

	Deflection.	Deflection. / Heat.	Deflection. / Heat × time.
Elliot pile & galvanometer	1	1	1
Radio-micrometer	4·2	560	2,000

by experiment from the instrument now on the table, show to what extent it is more sensitive than the standard thermopile and galvanometer, as measured in the three ways described in the last lecture. This sensibility has not been obtained at the sacrifice of stability, for none of the other instruments will compare with this in its freedom from the influence of every kind of disturbing cause.

Calculation shows that the instrument ought to give a clear indication when the sensitive surface has been warmed one two-millionth of a degree Centigrade, and the experiment shows that it will clearly respond to a quantity of heat no greater than that which would be radiated on to a halfpenny by a candle-flame 1,530 feet away from it.

There is one other class of instrument for measuring radiant energy, which has lately been brought to great perfection more especially by Prof. Langley. Instruments of this class depend upon the change of resistance of a conductor when warmed. The earliest account of an instrument of this kind, for the reference to which I have to thank Dr. Baur, is one by A. F. Svanburg,* who made one of the arms of a Wheatstone's bridge, of a flat spiral of copper wire $\frac{1}{120}$th of an inch thick, covered with lamp black. When this spiral was exposed to radiation, it was warmed to a certain extent, and so its resistance was changed, disturbing the balance of the bridge. He found this very simple contrivance to be extraordinarily sensitive, and better, he believed, than the Nobili thermopile.

It does not appear that much use had been made of instruments depending upon the effect of temperature upon resistance until 1881, when Langley turned his attention to this class of instrument. However, Jamin and Siemens had contrived apparatus in which the change of resistance disturbed the equilibrium of a differential galvanometer.

* "Pogg. Ann." 24, p. 416, 1851.

The general theory of the actinic balance or bolometer is given in the *American Journal of Science*, vol. xxi., p. 187. From this paper it appears that Langley did not find the thermopile sufficiently delicate to detect and measure the energy in a diffraction spectrum. In the case of the thermopile and galvanometer, the work that is necessary to deflect the needle must be supplied by the energy of the radiation, in fact, a great deal more must be supplied, because nearly all the heat received by the pile or junction is carried by the Peltier action of the current to the cooler junction, and but a small fraction is converted into electrical energy, only part of which is transferred to the needle. In the form of instrument first used by Svanburg, the energy that is necessary to move the needle is not derived from the radiation at all, but from the cell or battery employed to send the current through the Wheatstone bridge. All that the energy of the radiation has to do is to direct that of the battery, for when one of the resistances in the bridge is increased, and the balance disturbed, some of the energy of the battery spends itself in the galvanometer. The materials which Langley found most suitable for the resistances were steel, platinum, or palladium, in the form of the thinnest possible ribbon. In the case of iron, the change of resistance is 0·4 per cent. for each degree Centigrade. The object of using ribbon as thin as it can be made is to cause it to come to its final temperature as quickly as possible.

The effect of the size of the ribbon is not at first very evident. Suppose a bolometer made with a strip of metal of some particular size, and that another identical instrument is made, in which the strip that is to be exposed is half the length and half the breadth. Then its resistance will be the same; and since in the smaller strip there is only one quarter of the metal to heat, and it exposes one quarter of the surface to the radiation, it might seem as if it should acquire the same temperature as the larger piece, and so the change of resistance in each case should be the same, and thus the smaller piece receiving the smaller quantity of heat seems as if it should be able to produce the same effect as the larger. Now there are several false assumptions in this reasoning. In the first place, when these strips of metal are warmed, however slightly, above the rest of the instrument, heat begins to escape by radiation, convection, and by conduction. The radiation would, for any rise of temperature, be itself proportional to the surface, and so would produce the same effect in the two cases; the same would be almost true of the heat lost by convection; but this would not be the case at all with the loss by conduction, so that on this account the smaller surface would not be heated to so great an extent as the larger. However, even supposing that they were heated to the same extent, when no current passed, the smaller piece would not be capable of causing so great a movement of the galvanometer needle. It must be remembered that the battery current itself, in passing through the several resistances, must heat them to a certain extent; but as the exposed strip is electrically balanced against another strip in the same tube, but not exposed, this alone does not disturb the balance, unless the current is so strong as to heat them sufficiently to set up strong convection currents in the apparatus. Now in the case of the larger strip, a stronger current can be sent than through the smaller before this occurs, and since they are of the same resistance, a stronger current in the galvanometer will be the result.

In another way the heat produced by the battery current and that developed by the radiation to which the instrument is exposed, are curiously involved together. Suppose that the radiation acting alone were able to heat the exposed strip so as to increase its resistance to a certain extent, and the current acting alone were able to heat both strips to some other (generally a far greater) extent, then when both act together there will not be the same difference of temperature as if the battery current were not passing, and for this reason. Any increase of temperature in the exposed strip, by increasing its resistance, diverts a certain proportion of battery current into the other strip, and thus more heat is developed in the covered strip by the battery current than in the exposed strip, and this tends to counteract the effect of radiation. Thus apparently heat is carried from the warmer to the cooler strip, just as in the thermo-electric apparatus the Peltier action carries heat from the warm to the cool junction. An exception to this, however, is found in the case of carbon, which falls in resistance as its temperature rises. In this case the heat received by the exposed strip warms it, lowers its resistance, and causes a greater proportion of the whole current to pass through it, which warms it still more.

Langley has, by making every detail as perfect as possible, and by employing the

most delicate galvanometer that American ingenuity could construct, been able to map the dark heat* of the spectrum, and to extend it far beyond the limits which previously were known.

Dr. Baur has published two papers† on the bolometer. He made his grating of tinfoil, cut in the form of a series of parallel strips joined at alternate ends, a form which Langley also used, supported at the ends of the strips only, and blackened with platinic chloride. Such a sensitive surface acquires its final temperature almost instantly, and the time that elapses before a reading can be taken depends simply upon the galvanometer. Dr. Baur tried to use Dutch gold and gilt paper, but these were found impracticable. There is a difference in detail between the arrangements of Langley and Baur in respect of the second resistance, against which the exposed surface is balanced. In Langley's instrument this second resistance is made in two halves, placed on either side of the exposed surface so as normally to have the same temperature. In Baur's arrangement the two resistances are arranged side by side, and by the movement of a shutter the radiation is allowed to fall on one or the other alternately, and thus the effect is doubled. In order that these two resistances should be exactly alike, a piece of foil was doubled, and the two cut out of the doubled piece at the same time.

I understand from Dr. Baur that this class of instrument is in use in the laboratory of Professor Helmholtz, and generally in Germany to a much greater extent than it is with us.

I have had no experience with any of the instruments of the bolometer type, and so cannot speak of them from experience; but it is possible that in sensibility Prof. Langley's instrument may not be far short, if it does not actually exceed, that of the radiomicrometer. But it cannot compare with the radiomicrometer in its freedom from disturbing influences. On the other hand, the bolometer has the very great advantage over all the instruments except the thermopile, that it can be moved about and pointed up or down, whereas the radio-micrometer must be kept level, and is most easily used when fixed, so that the radiation must be brought to it, a plan which in some cases is not convenient.

A few words on the relative advantages of the different classes of instruments may perhaps be conveniently given here.

It sometimes happens that the radiation to be measured is brought to an exact focus, which is a line in the case of a spectrum, or a point when a star is being observed. In these cases, instruments like Joule's convection apparatus, the differential air thermometer, or Weber's micro-radiometer are useless, since they are only efficient when advantage is taken of the large surface they expose to the radiant energy. The receiving surface should be no larger than the image formed, and so even the thermopile itself is practically of little use. A thermo-junction is good, but the bolometer for spectra, and the radio-micrometer generally, are the only instruments that can be used with advantage.

If diffused heat is to be measured, then the instruments first mentioned are at their best, but those with small receiving surfaces are better if reflecting mirrors or rock-salt lenses can be employed to concentrate the rays upon the small surface.

If the instrument has to be freely movable, the thermopile and bolometer are the only ones which can be used at all; if it need be moved only slowly, and may be kept level, then the radio-micrometer and one or two others also become available.

If the instrument is to be exposed to outside changes of temperature, the radio-micrometer is the only one which is practically uninfluenced.

If magnetic changes, which are by no means uncommon, are liable to be met with, the radio-micrometer and Joule's instrument are the only ones available.

With regard to my instrument, and M. D'Arsenval's, I have no doubt that mine is far the most sensitive and the least influenced by disturbing causes; for I employ a thermo element which has an electromotive force ten times as great as any that he can make use of. He is able to suspend his circuit by a fibre of silk, which would make the radio-micrometer practically unmanageable. He has not, so far as I know, screened off the disturbing effects of temperature changes by surrounding the circuit with a mass of metal, and if this were done, since the junctions are much further apart in his instrument than in mine, any temperature waves moving in the metal block would have a greater effect; but what to me is most conclusive of all, is the fact that he fixes the mirror over the junction that is not to be exposed to radiation.

* "Am. Journ. Sci.," xxv., p. 169; xxvii., p. 169; xxxi., p. 1.

† "Proc. Berlin Phys. Soc.," March 3, 1882. "Annelen der Ph. und Ch.," vol. xix., p. 12, 1883.

And now, in conclusion, I have to regret that it has not been in my power to treat the subject of these lectures either so clearly or so thoroughly as I should have liked. The only claim that I have to address the Society of Arts at all upon the subject is the fact that I have done something to develop some of the instruments which I have brought before your notice.

Miscellaneous.

THE MANUFACTURING INDUSTRIES OF THE NETHERLANDS.

The United States Consul at Amsterdam, in his last report, says that there seems to prevail a very general opinion abroad that Holland has no manufacturing industry worth speaking of, and that its material interests are almost solely of a commercial, agricultural, and financial nature. This opinion, he states, is far from correct, for when taking into proper account various existing circumstances, such as extent of territory, population, the vast extent of Dutch capital otherwise invested in and out of the country, they would seem to be of a great deal more importance than is generally supposed. Taking first the textile industries. The district of Twenthe, in the province of Overyssel, form the chief seat of the cotton industry in Holland, the principal towns engaged being Enschedé, Almelo, and Hengelo; further, the villages of Neede, Borne, Haaksbergen, Oldenjaal, and Nyverdal. In Enschedé large quantities of unbleached cotton, in all widths, are made, as well as cambric, principally for the Dutch-Indian market. This place also possesses blue dye mills and weaving sheds for checks, and many of the mills in this district are of considerable size and importance. In Almelo there are several large factories making unbleached cottons and shirtings, and in Hengelo, Neede, Haaksbergen, and Borne there are weaving sheds and factories of considerable size. At Nyverdal there is a large mill where unbleached cotton, water twist, and cambrics are made; at Oldenjaal there is a hemp spinning factory, and two weaving sheds for export cambrics, drillings, and shirtings. Ryssen has a large hemp spinning mill and weaving sheds, and at Goor there are large sheds for check weaving intended for export, and there is also a weaving shed for fishing nets. Further, there are in Twenthe large bleaching works, the most noted being at Goor and Nyverdal. The province of North Brabant possesses many factories. Tilburg ranks first, producing large quantities of baize, beavers, and flannels. Buckskins, cloths, duffels, friezes, and similar articles, which were formerly only made of the most ordinary qualities, are now made of a better quality and in larger quantities. This district is the most prosperous and thriving in the whole country. At Helmond there are many weaving sheds for checks, both cotton and linen; most of these are worked by steam. The largest print works in Holland are in this town. Furniture prints, chintzes, calicoes and drills are made in large quantities, and special attention is paid to render them suitable for the Indian market. Both in Helmond and Limburg special attention has recently been given to the blanket trade. Leyden, in South Holland, is the great seat of this trade, and there also knitting yarns and worsted and cotton yarns are chiefly produced. There is also a large establishment for printing calicoes and cotton goods both for home and Indian consumption. Kralingen, near Rotterdam, possesses a large print factory for calicoes and furniture stuffs. At Arnheim, in Gelderland, there is a factory for cotton, woollen, and linen tapes. Veenendaal, in the province of Utrecht, has a factory of some importance for woollen yarns, as well as weaving sheds for cottons. The carpet industry (imitation Smyrna) is established at Deventer, Overyssel, and at Amersfoort, in the province of Utrecht, and has a considerable reputation. Its products find a ready market, and are sold in many European countries. The carpet factories at Hilversum, North Holland, supply the home demand. The leather industry—tanning, boot and shoe making, and the manufacture of various articles—is carried on on a somewhat extensive scale. It is chiefly situated in North Brabant, at Tilburg, Boxmeer, but more particularly in a section of that province named the Langstraat. The diamond industry—cleaving, cutting, and polishing—is located at Amsterdam, and it is stated that in this important industry 900 cutting and polishing establishments are engaged, in 30 of which steam power is used. Gold and silver wares are produced for export purposes in the factories at Utrecht, Gouda, and Voorschoten. Candle making is an important industry in Holland, a factory at Gouda employing between 500 and 600 hands; and there is also a large factory at Amsterdam, and another at Schiedam. The glass, earthenware, and porcelain manufacture is of some importance, and large quantities find their way, it is stated, to France, England, Germany, and Belgium. The principal seat of the industry is at Masstricht, and the works of Hooft and Labouchere, at Delft, have a world-wide reputation. The distilling interests of the Netherlands are of considerable importance. At Schiedam, where most of the gin is made, there are said to be over 350 distilleries, and the industry is not confined to that place, as at Rotterdam and other places this article is also produced in considerable quantities. Liqueur distilling is also very extensively engaged in at many places in Holland, more especially at Amsterdam and Rotterdam. The brewing business is very large and constantly increasing, the products of the Amsterdam breweries being exported to France, India, and other

countries. The yeast manufacture, situated principally at Schiedam and Delft, has acquired large dimensions. This article is exported in considerable quantities, chiefly to England. The cocoa and chocolate manufacture forms an important industry, which appears to be prosperous and progressive. There are large establishments for the production of these articles at Weesp, at Amsterdam, Rotterdam, and other places, and the export trade in them is on the increase. Machinery of various kinds is somewhat largely produced at works established at Amsterdam, Haarlem, Hengels, Rotterdam, Fyenoord, and Flushing. Mills and factories, agricultural requirements and shipping, are, to a considerable extent, supplied by them. Orders for machinery from France, Spain, Portugal, and the Netherlands Indies are said to be of frequent occurrence, dredging machines having not long since been made for, and sent to, South America and Central America. Shipbuilding has been for some time past in a very prosperous condition, and wagon and carriage making is also of some importance. Railway carriages and street cars are made at Amsterdam and Haarlem, and at Amsterdam and the Hague there are extensive carriage and wagon factories, the products of which not only largely supply the home demand, but are exported to India and other countries. Cigar factories abound in great number throughout the country, but more particularly in the city of Eindhoven, and although the home consumption is very great, considerable quantities are exported, particularly to the colonies. The tinned goods industry has of late attained some considerable importance. It is carried on at Amsterdam, Rotterdam, Leyden, Haarlem, and other places, and large quantities are exported to various European countries and the Dutch colonial possessions. The artificial butter or butterine industry, of comparatively recent origin, has attained large proportions. The number of factories is variously stated, and they are established at different places and in nearly all parts of the country. The annual production of this article is, says Consul Eckstein, enormous, and one of the prominent dealers in oleomargarine at Amsterdam stated that the value of the product for the year 1887 amounted to 75,000,000 florins. It is said that the great bulk of it was exported to England. The manufacture of paper is deserving of attention. There are mills at various places in Holland, and they turn out nearly every kind of paper, inclusive of wall paper. Straw paper is said to be extensively exported to England, printing and writing paper does not find a foreign market to the same extent, whereas hand-made paper in considerable quantities is shipped to England, France, and other countries. Quinine is produced in the Netherlands, a large factory making this article being established at Amsterdam, and large quantities being exported. In addition to the above, furniture of every description is manufactured in many places in Holland, as also are billiard tables, pianos and organs, sewing-machines and iron safes. Rope and sail-making is largely carried on, while the making of fishing nets forms a kind of house industry in which the fishermen of the country are engaged during the winter season.

GOLD REFINING IN AUSTRALIAN MINTS.

The method adopted at the Australian mints for refining gold and silver is stated, by Consul Griffin of Sydney, to be the invention of Mr. F. P. Miller, formerly one of the assistants at the Sydney Mint, and now Superintendent of the Bullion-office at Melbourne. It consists in passing chlorine gas through the metal. The total amount of gold operated upon at the mints of Sydney and Melbourne since the introduction of the process has been about 15,000,000 ounces. Consul Griffin says that the furnace used in the Miller process differs very little from the one commonly used in gold melting; the flue is brought near the top, so that the crucibles holding the molten gold can be placed high up in the furnace without being cooled by the draught. The crucibles are made of clay, and are capable of holding about 700 ounces of gold each. They are provided with loosely fitting covers made of the same material, each having two small holes bored through them. The crucibles are first filled with a solution of boiling borax for the purpose of glazing their surfaces, and rendering them impervious to melted chloride of silver. The pipes through which the chlorine passes are also made of clay, the lower ends of which are heated, so as to prevent them from splitting. The jars for generating the gas are of the best glazed stoneware, and hold from about 10 to 15 gallons each. The chlorine gas from the generator is conducted into a leaden pipe fitted with branches for several furnaces respectively, all intermediate connections being formed by means of vulcanised india-rubber tubing. The crucibles are slowly heated to a dull red colour, and the gold is introduced in the form of what is known as the "slipper-shaped ingot," the narrow end being placed downwards. As soon as the gold is melted, a small proportion of molten borax is poured upon it; the clay pipe is then introduced, and a small quantity of chlorine gas is passed through, so as to prevent the gold from rising and solidifying in the pipe. The pipe is gradually depressed until it touches the bottom, where it is kept down by means of a weight at the top. The compressor is then relaxed, and the gas bubbles up through the molten gold without causing any projection of the globules. Hydrochloric acid is introduced from time to time into the generator to keep up a rapid evolution of chlorine. When the gas first passes into the molten gold, fumes escape from the holes in the lid or covers of the crucibles. These fumes consist of volatile chlorides of the baser metals, and not of the chloride of silver. So long as any of the silver remains in the

gold, the whole, or nearly the whole, of the chlorine continues to be absorbed. When the operation is nearly over, fumes of a darker colour than those produced at first make their appearance, and the end of the operation is indicated by the colour of the flame or luminous vapour, which is at first of a bright yellow, and then a deep reddish brown. The quantity of chlorine gas employed in the process depends upon the quantity of gold operated upon. The time required to deliver sufficient chlorine to refine about 400 ounces of gold of 900 assay is usually from one to two hours, according to the size of the pipes employed, and the rate at which the gas is generated. As soon as the operation is over, the gold is allowed to stand until it solidifies. It is then poured upon an iron table, remelted, and cast into bars. The chloride of silver is melted in clay crucibles prepared with borax, together with from 8 to 10 per cent. laminated metallic silver. When the contents are thoroughly heated, the crucibles are removed from the furnaces, and after standing for a few minutes, the still liquid of chloride of silver is poured into moulds, and cast into slabs. The gold in the chloride of silver alloys with the metallic silver, and forms a cake at the bottom of the crucible. In conclusion, Consul Griffin observes:—"It was believed for many years that previous to Mr. Miller's discovery the use of chlorine for refining gold was altogether unknown, but the fact is it was successfully employed by Malaguti, Duroche, and others in Paris, many years before; and Mr. Louis Thompson, in a communication to the Society of Arts, of London, as early as 1838, said, 'The plan I submit for assaying and purifying gold is no less simple in execution than certain in effect, and is founded on a circumstance long known chemists, viz., that not only has gold no affinity for chlorine at a red heat, but that it actually parts with it at that temperature, although previously combined.'"

SERICULTURE AND THE SILK TRADE IN BULGARIA.

M. Lanet, Acting Consul for France at Sofia, has recently addressed to his Government an interesting report on sericulture and the silk trade in Bulgaria. According to this report, sericulture is an industry still in a very primitive condition. Special plantations of mulberry trees are not met with; each proprietor carries on the breeding of silkworms, and the production is commensurate with the requirements of local consumption. This is the case in the *arrondissements* of Varna, Silistria, Roustchouck, Sistova, Rahova, Lom, Widdin, and Kustendjé. In others such as Vratza, Plevna, Lovtcha, Selvi, and Tirnova, the production of the cocoons and of the silk is greater than the needs of local consumption, and gives rise to an export trade. The breeding of silkworms extends over the whole of the Plevna *arrondissement*, but it is centred chiefly in the environs of Lonkovit. The greater part of the cocoons and of the silk is sold to Plevna and Lonkovit merchants. In the *arrondissement* of Lovtcha, as well as in those of Lom and Tirnova, the silk industry has considerably suffered from the disease with which the silkworms have been attacked. Owing to the distribution of European seed by the Bulgarian Government, in 1884, the production has recovered, especially in the two last-mentioned *arrondissements*. The quantity of cocoons which the different centres of production are capable of exporting is estimated at from 40,000 to 50,000 okes (the oke is equivalent to 2·84 lbs. avoirdupois). These cocoons are white, green, yellow, or rose coloured, and are usually purchased by merchants from Philippopolis, Adrianople, and Constantinople, who resell them to French and Italian houses. They are exported by way of Varna, Galatz, or Dedeagatch. About one-fourth of the production of Bulgarian cocoons is reduced to silk, and sold on the markets of European Turkey, where it is used for the manufacture of *gaetan* (silk twist) and Oriental stuffs. The price of the cocoons varies according to their quality; the fresh cocoons are worth from 2 francs to 2 francs 50 centimes per oke, and the dry cocoons from 9 to 12 francs. Four okes of cocoons yield about one oke of silk. The spun silk is worth from 40 to 50 francs the oke. The cocoons are usually purchased dry and cleaned, and are sold about the 1st September. Of the tissues of mixed silk imported, those which have the largest sale are satins, plain with cotton woof, dyed in the piece. These satins are more sought after when coloured than black. Satins with cotton woof striped are very extensively used, especially in the districts where the Mussulman element predominates. Velvets plain, as well as plushes with woof of cotton, are only used to a very limited extent. Silk velvets, glazed taffetas of one or more colours, corded silk fabrics, *satins merveilleux*, crapes and *fichus* of crape, grenadines and foulards, and ribbons of silk and half-silk, are also imported to some extent into Bulgaria.

General Notes.

SCHOOL OF WOOD-CARVING.—The School of Art Wood-carving, City and Guilds' Institute, Exhibition-road, South Kensington, has been re-opened after the usual summer vacation, and one or two free studentships, in both the day and the evening classes, are vacant. These studentships are maintained by means of funds granted to the school by the City and Guilds Institute. To bring the benefits of the school within the reach of artisans a remission of half fees for the evening class is made to artisan students connected with the wood-carving trade. Forms of application for the free studentships, and any further particulars relating to the school may be obtained from the manager.

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Proceedings of the Society.

CANTOR LECTURES.

THE DECORATION AND ILLUSTRATION OF BOOKS.

By Walter Crane.

Lecture I.—Delivered March 4th, 1889.

My subject is a large one, and touches more intimately, perhaps, than other forms of art, both human thought and history, so that it would be extremely difficult to treat it exhaustively upon all its sides. I shall not attempt, in the course of the three lectures I have undertaken to give here, to deal with it from the historical or antiquarian points of view more than may be necessary to elucidate the artistic side, on which I propose chiefly to approach the question of design as applied to books—or, more strictly, the book page—which I shall hope to illustrate by photographs in the lantern of characteristic examples from different ages and countries.

I may, at least, claim to have been occupied, in a practical sense, with the subject more or less as part of my work, both as a decorator and illustrator of books, for the greater part of my life, and such conclusions as I have arrived at are based upon the results of personal thought and experience, if they are also naturally coloured and influenced from the same sources.

All forms of art are so closely connected with life and thought, so bound up with human conditions, habits, and customs; so intimately and vividly do they reflect every phase and change of that unceasing movement—the ebb and flow of human progress amid the forces of nature we call history—that it is hardly possible even for the most careless stroller, taking any of the by-paths, not to be led insensibly to speculate on their hidden sources, and an origin perhaps common to them all.

The story of man is fossilised for us, as it were, or rather preserved, with all its semblance of life and colour, in art and books. The procession of history reaching far back into the obscurity of the forgotten or inarticulate past, is reflected, with all its movement, gold and colour, in the limpid stream of design, that mirror-like, paints each passing phase for us, and illustrates each act in the drama. In the language of line and of letters, of symbol and picture, each age writes its own story and character as page after page is turned in the book of time. Here and there the continuity of the chapters is broken, a page is missing, a passage is obscure; there are breaks and gaps—heroic torsoes and limbs instead of whole figures. But more and more, by patient research, labour, and comparison, the voids are being filled up, until some day perhaps there will be no chasm of conjecture in which to plunge, but the volume of art and human history will be as clear as pen and pencil can make it, and only left for a present to continue, and a future to carry to a completion which is yet never complete.

If painting is the looking-glass of nations and periods, pictured-books may be called the hand-glass which still more intimately reflects the life of different centuries and peoples, in all their minute and homely detail and quaint domesticity, as well as their playful fancies, their dreams, and aspirations. While the temples and the tombs of ancient times tell us of the pomp and splendour and ambition of kings, and the stories of their conquests and tyrannies, the illuminated MSS. of the Middle Ages show us, as well as these, the more intimate life of the people, their sports and their jests, their whim and fancy, their work and their play, no less than the mystic and religious and ceremonial side of that life, which was, indeed, the inseparable part of it; the whole worked in as with a kind of embroidery of the pen and brush, with the most exquisite sense of decorative beauty.

Mr. Herbert Spencer, in the course of his enunciation of the philosophy of evolution, speaks of the book and the newspaper lying on the table of the modern citizen as connected through a long descent with the hiero-

FIG. 1.—ARUNDEL PSALTER, A.D. 1339. *Brit. Mus., Arundel, 83.*

glyphic inscriptions of the ancient Egyptians, and the picture-writing of still earlier times. We might go (who knows how much further?) back into prehistoric obscurity to find the first illustration, pure and simple, in the hunter of the cave, who recorded the incidents of his sporting life on the bones of his victims.

We know that the letters of our alphabet were once pictures, symbols, or abstract signs of entities and actions, and grew more and more abstract until they became arbitrary marks—the familiar letters that we know. Letters formed into words; words increased and multiplied with ideas and their interchange; ideas and words growing more and more abstract until the point is reached when the jaded intellect would fain return again to picture-writing, and welcomes the decorator

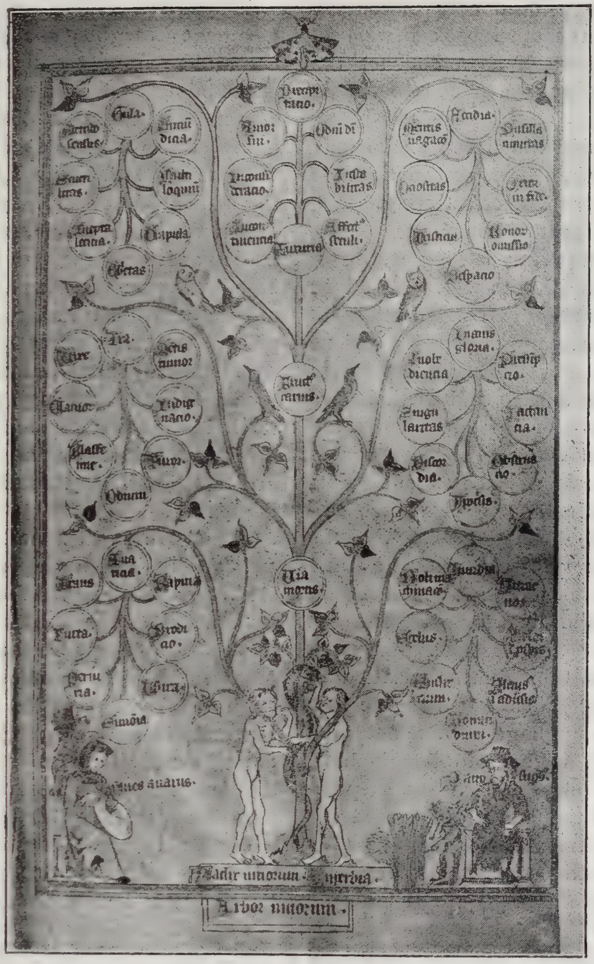

FIG. 2.—ARUNDEL PSALTER A.D. 1339. *Brit. Mus., Arundel MS.* 83.

and the illustrator to relieve the desert wastes of words marshalled in interminable columns on the printed page.

In a journey through a book it is pleasant to reach the oasis of a picture or an ornament, to sit awhile under the palms, to let our thoughts unburdened stray, to drink of other intellectual waters, and to see the ideas we have been pursuing, perchance, reflected in them. Thus we end as we begin, with images.

Temples and tombs have been man's biggest books, but with the development of individual life (as well as religious ritual, and the necessity of records),he felt the need of something more familiar, companionable, and portable, and having, in the course of time, invented the stylus, and the pen, and tried his hand upon papyrus, palm leaf, and parchment, he wrote his records or his thoughts, and pictured or symbolised them, at first upon scrolls and

rolls and tablets, or, later, enshrined them in bound books, with all the beauty that the art of writing could command, enriched and emphasised with the pictorial and ornamental commentary in colours and gold.

As already indicated, it is my purpose to deal with the artistic aspects of the book page, and therefore we are not now concerned with earlier roll form of book, or with the treatment of its exterior case, cover, or binding, which has lately been ably discoursed upon here. It is the open book I wish to dwell on—the page itself as a field for the designer and illustrator—a space to be made beautiful in design.

Both decorated and illustrated books may be divided broadly into two great periods:—

I. The MS., or period before printing.

II. The period of printed books.

Both illustrate, however, a long course of evolution, and contain in themselves, it might be said, a compendium—or condensation—of the history of contemporary art in its various forms of development. The first impulse in art seems to answer to the primitive imitative impulse in children—the desire to embody the familiar forms about them—to characterise them in line and colour. The salient points of an animal, for instance, being first emphasised—as in the bone scratchings of the cave men—so that children's drawings and drawings of primitive peoples present a certain family likeness, allowing for difference of environment. They are abstract, and often almost symbolic in their characterisation of form, and it is not difficult to imagine how letters and written language became naturally evolved through a system of hieroglyphics, starting from the unsystemised but irrepressible tendency of the human to record his linear ideas of rhythm on the one hand, or his impressions of nature on the other. It would seem that the illustrator or picture writer came first in the order of things, and the book afterwards—like the system we have heard of under modern editors of magazines, of the picture being done first and then written up to, or down to, by the author.

Side by side with the evolution of letters and caligraphic art went on the evolution of the graphic power and the artistic sense, developing on the one hand towards close imitation of nature and dramatic incident, and on the other towards imaginative beauty, and systematic, organic ornament, more or less built upon a geometric basis, but ultimately bursting into a free foliation and flamboyant blossom, akin in inventive richness and variety to a growth of nature herself. The development of these two main directions of artistic energy may be followed throughout the whole world of art, constantly struggling, as it were, for the ascendancy, now one and now the other being paramount; but the history of their course, and the effect of their varying influences is particularly marked in the decoration and illustration of books.

Although as a rule the decorative sense was dominant throughout the illuminated books of the Middle Ages, the illustrator, in the form of the miniaturist, is in evidence, and in some, especially in the later MSS , finally conquers, or rather absorbs, the decorator.

There is a MS. in the Egerton collection in the British Museum (No. 943),* "The Divina Commedia" of Dante, with miniatures by Italian artists of the 14th century, which may be taken as an early instance of the ascendancy of the illustrator, the miniatures being placed somewhat abruptly on the page, and with unusually little framework or associated ornament; and although more or less decorative in the effect of their simple design, and frank and full colour, the main object of their artists was to illustrate rather than to decorate the text.

The Celtic genius, under the influence of Christianity, and as representing the art of the early Christian Western civilisation—exemplified in the remarkable designs in the Book of Kells—was, on the other hand, strictly ornamental in its manifestations, suggesting in its richness, and in the intricacy and ingenuity of its involved patterns, as well as the geometric forms of many of its units, a relation to certain characteristics of Eastern as well as primitive Greek art.†

I give in the lantern some slides from negatives taken from the original volume in the library of Trinity College, Dublin.

The Book of Kells derives its name from the Columban Monastery of Kells or Kenlis, originally Cennanas, a place of ancient importance in the county of Meath, Ireland, and it is supposed to have been the Great Gospel

* Exhibited in Case 2, King's Lib., No. 27.

† I have not been able to go into the question of the influence of Oriental art and MS. upon the European illuminator, although it seems highly probable that since the Christian religion itself came from the East, the influence of Eastern art should be felt also, however transferred and incorporated in new forms. The illuminated Oriental MS.—the Persian and Indian, for example—corresponding in date to European work, show much the same methods and style of treatment, while different in conception and feeling.

brought to the Christian settlement by its founder, St. Columba, and perhaps written by that saint, who died in the year 597.

In one of the pages of this book is represented the Greek monogram of Christ, and the whole page is devoted to three words, Christi Autem Generatio. It is a remarkable instance of an ornamental initial spreading over an entire page. The effect of the whole as a decoration is perhaps what might be called heavy, but it is full of marvellous detail and richness, and highly characteristic of Celtic forms of ornamental design.

The work of the scribe, as shown in the form of the ordinary letters of the text, is very fine. They are very firm and strong in character, to balance the closely knit and firmly built ornamentation of the initial letters and other ornaments of the pages. We feel that they have a dignity, a distinction, and a character all their own.

Such a page as the next example, from the same book, where the symbols of the evangelists are enclosed in circles, and panelled in a solid framing occupying the whole page, suggests Byzantine feeling in design.

The full pages in the earlier illuminated MSS. were often panelled out in four or more compartments to hold figures of saints, or emblems, and in the 12th or 13th centuries such panels generally had small patterned diapered backgrounds, on dark blue, red, green, or burnished gold.

The Anglo-Saxon MSS. show traces of the influence of the traditions of Classic art drawn through the Byzantine, or from the Roman sources which naturally affected the earliest forms of Christian art, as we see its relics in the catacombs.* These classical traditions are especially noticeable in the treatment of the draperies clinging in linear and elliptical folds to express the limbs. In fact, it might be said that, spread westward and northward by the Christian colonies, this classical tradition in figure design lingered on, until its renewal at the dawn of the Renaissance itself, and the resurrection of classical art in Italy which, uniting with a new naturalism, grew to that wonderful development which has affected the art of Europe ever since, and to which we still look back.

The Charter of Foundation of Newminster, at Winchester, by King Edgar, A.D. 966, written in gold, is another very splendid early example of book decoration. It has a full-page miniature of the panelled type above mentioned, and elaborate border in gold and colours by an English artist. It is in the British Museum, and may be seen open in Case 2 in the King's Library.

"The Gospels," in Latin. A MS. of the 11th century, with initials and borders in gold and colours, by English artists, is another fine specimen of the early kind. Here the titles of each gospel, boldly inscribed, are enclosed in a massively designed border, making a series of full title pages of a dignified type.

As examples of illustrated books, according to the earlier Mediæval ideas, we may look at 12th and 13th century "Herbals," wherein different plants, very full and frank in colour and formal in design, are figured strictly with a view to the ornamentation of the page. There is a very fine one, described as written in England in the 13th century, in the British Museum. Decoration and illustration are here one and the same.

A magnificent specimen of book decoration of the most splendid kind is the "Arundel Psalter" (Arundel MS. 83, Brit. Mus.), given by Robert de Lyle to his daughter Audry, as an inscription in the volume tells us, in 1339. Here scribe, illuminator, and miniaturist are all at their best, whether one and the same or different persons. It is, moreover, English work. There is no doubt about the beauty of the designs, and the variety and richness of their decorative effect. Like all the Psalters, the book commences with a calendar, and full pages follow, panelled out and filled in with subjects from the life of Christ. A particularly splendid full-page is that of the Virgin and Child under a Gothic canopy, with gold diapered background. There are also very interestingly designed genealogical trees, and fine arrangements of double columnal text-pages with illuminated ornament.

My next examples are from the Tenison Psalter (Addit. MS. 24686). It (the MS.) is a specimen of English 13th century work. "Probably executed for Alphonso, son of Edmund I., on his contemplated marriage with Margaret, daughter of Florentius, Count of Holland, which was frustrated by the prince's death on 1st August, 1284."

The full-page miniatures arranged in panels —in some instances four on a page, with alternate burnished gold and dark blue diapered backgrounds behind the figures, and in others six on a page, the miniature much

* There is a large early MS. of the Gospels in the British Museum, with a full-page miniature with large figure of Christ in the centre, which strongly resembles in treatment and colour the later Roman wall-paintings and mosaics.

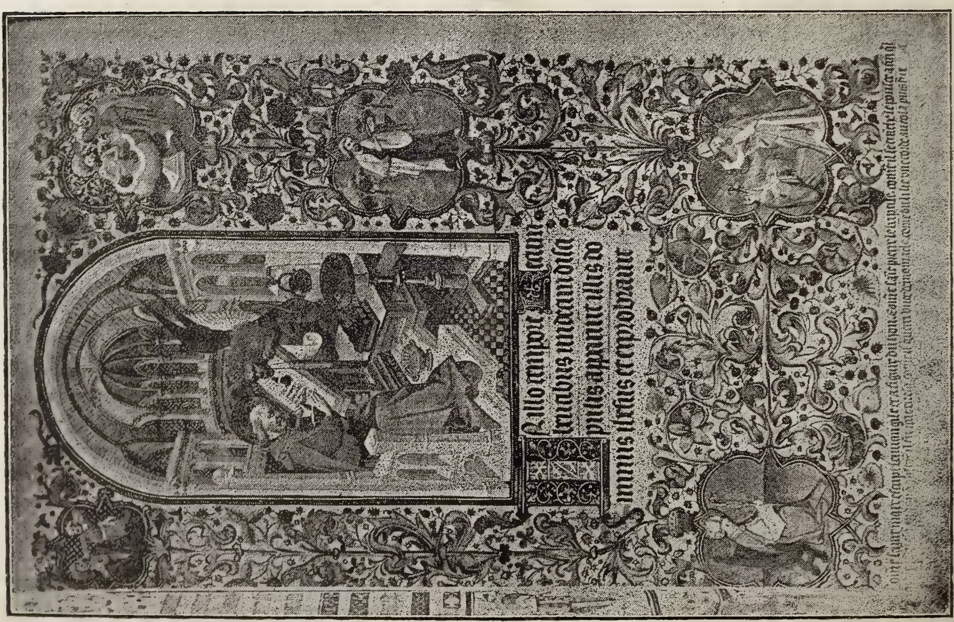

FIG. 3.—BEDFORD MISSAL, A.D., 1422. *Brit. Mus.*, 18,850.

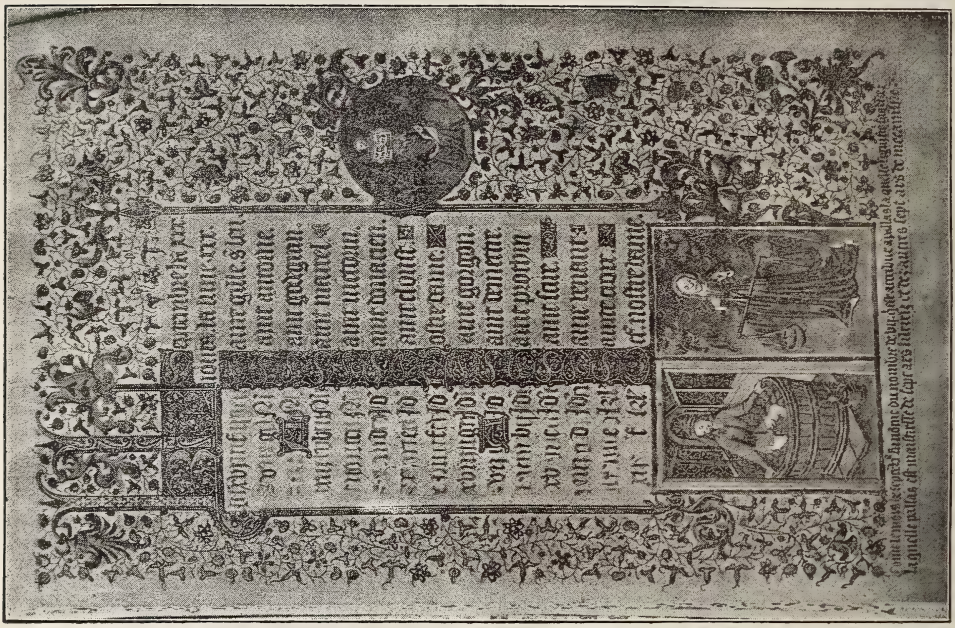

FIG. 4.—CALENDAR PAGE, BEDFORD MISSAL, A.D., 1422. *Brit. Mus.*, 18,850.

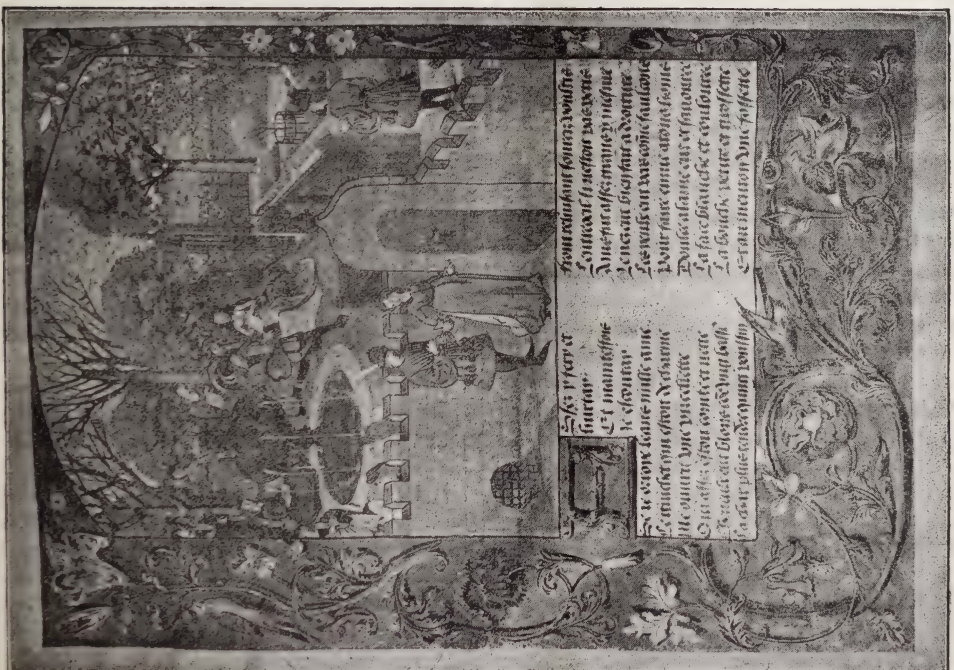

FIG. 5.—ROMANCE OF THE ROSE. LATE 15TH CENTURY. *Brit. Mus., Harl. MS.*, 4,425.

FIG. 6.—END OF 14TH CENTURY. *Brit. Mus., Royal*, 20, *B. VI.*

smaller, and set in a larger margin of colour, alternate red and blue—are very full, solid, and rich in colour with burnished gold. The book is further interesting, as giving excellent and characteristic instances of another and very different treatment of the page (and one which appears to have been rather peculiarly English in style), in the spiny scrolls which, often springing from a large illuminated initial letter upon the field of the text, spreads upon and down the margin, or above and below, often holding in its branching curves figures and animals, which in this MS. are beautifully and finely drawn. Note the one showing a lady of the time in pursuit of some deer.

In the 13th century books the text is a solid tower or column, from which excursions can be made by the fancy and invention of the designer, up and down and above and beneath, upon the ample vellum margins; in some cases, indeed, additional devices appear to have been added by other and later hands than those of the original scribe or illuminator.

There is a very remarkable Apocalypse (Brit. Mus. MS. 17353. Formerly belonging to the Carthusian house of Van Dien between Liege and Aix) by French artists of the early 14th century, which has a series of very fine imaginative and weird designs (suggestive of Orcagna), highly decorative in treatment, very full and frank in colour, and firm in outline. The designs are in oblong panels, enclosed in linear coloured borders at the head of each page, and occupying about two-thirds of it, the text being written in double columns beneath each miniature, with small illuminated initials. The backgrounds of the designs are diapered on grounds of dark green and red alternately.

The imaginative force and expression conveyed by these designs—strictly formal and figurative, and controlled by the ornamental traditions of the time—is very remarkable. The illustrator and decorator are still one.

Queen Mary's Psalter (Brit. Mus. MS. 2, B. VII), again, is interesting as giving instances of a very different and lighter treatment of figure designs. We find in this MS., together with illuminations in full colours and burnished gold, a series of pale tinted illustrations in Bible history drawn with a delicate pen line.

The method of the illuminators and miniaturists seems always to have been to draw their figures and ornaments clearly out first with a pen before colouring.

In the full-coloured miniatures the pen lines are not visible, but in this MS. they are preserved with the delicate tinted treatment. The designs I speak of are placed two on a page, occupying it entirely. They are enclosed in vermilion borders, terminated at each corner with a leaf. There is a very distinct and graceful feeling about the designs. The hand appears to have added on the lower margins of the succeeding text pages a series of quaint figures—combats of grotesque animals, hunting, hauling, and fishing scenes, and games and sports, and, finally, Biblical subjects. Here, again, I think we may detect in the early illustrators a tendency to escape from the limitations of the book page, though only a tendency.

As a specimen of early 15th century work, both for illuminator, scribe, and miniaturist, it would be difficult to find a more exquisite book than the Bedford Missal (Brit. Mus. MS. 18850), dated 1422, said to be the work of French artists, though produced in England. The kalendar, which occupies the earlier pages, is remarkable for its small and very brilliant and purely coloured miniatures set like gems in a very fine, delicate, light, open, leafy border, bright with burnished gold trefoil leaves, which are characteristic of French illuminated books of this period.

There is an elaborate full-page miniature containing the Creation and Fall, which breaks over the margin here and there. The 13th and 14th century miniaturists frequently allowed their designs to break over the framework of their diapered grounds or panels in an effective way, which pleasantly varied the formality of framed-in subjects upon the page, especially where a flat margin of colour between lines enclosed them; and some parts of the groups broke over the inner line while keeping within the limits of the outer one. Very frequently, as in this MS., a general plan is followed throughout in the spacing of the pages, though the borders and miniatures in detail show almost endless variation. In such splendid works as this we get the complete and harmonious co-operation and union between the illustrator and the decorator. The object of each is primarily to beautify his page. The illuminator makes his borders and initial letters branch and bud, and put forth leaves and flowers spreading luxuriantly up and down the margin of his vellum pages (beautiful even as the scribe left them) like a living growth; while the miniaturist makes the letter itself the shrine of some delicate saint, or a vision of some act of mercy or martyrdom; while the

careless world plays hide and seek through the labyrinthine borders, as the seasons follow each other through the kalendar, and the peasant ploughs, and sows, and reaps, and threshes out the corn, while gay knights tourney in the lists, or, with ladies in their quaint attire, follow the spotted deer through the greenwood.

In these beautiful liturgical books of the Middle Ages, as we see, the ornamental feeling developed with and combined the illustrative function, so that almost any illuminated Psalter or Book of Hours will furnish not only lovely examples of floral decoration in borders and initials of endless fertility of invention, but also give us pictures of the life and manners of the times. In those of our own country we can realise how full of colour, quaint costume, and variety was life when England was indeed merry, in spite of family feuds and tyrannous lords and kings; before her industrial transformation and the dispossession of her people; ere Boards of Works and Poor-law Guardians took the place of her monasteries and abbeys; before her streams were fouled with sewage, and her cities blackened with coal smoke—the smoke of the burning sacrificed to commercial competition and wholesale production for profit by means of machine power and machine labour; before she became the workshop and engine-room of the world.

These books glowing with gold and colour tell of days when time was no object, and the pious artist and scribe could work quietly and lovingly to make a thing of beauty with no fear of a publisher or a printer before his eyes, or the demands of world market.

In the midst of our self-congratulation on the enormous increase of our resources for the rapid and cheap production of books, and the power of the printing press, we should do well not to forget that if books of those benighted centuries of which I have been speaking were few, comparatively, they were fit, though few —they were things of beauty and joys for ever to their possessors. A prayer-book was not only a prayer-book, but a picture-book, a shrine, a little mirror of the world, a sanctuary in a garden of flowers. One can well understand their preciousness apart from their religious use, and many have seen strange eventful histories no doubt. The Earl of Shrewsbury lost his prayer-book (the Talbot prayer-book) and his life together on the battlefield at Castillon (about 30 miles from Bordeaux) in 1453. This book, as Mr. Quaritch states, was carried away by a Breton soldier, and was only re-discovered in Brittany a few years ago.

It has been suggested that the large coloured and illuminated initial letters in liturgical books had their origin as guides in taking up the different parts of the service; and, as I learn from Mr. Micklethwaite, in some of the Missals, where the crucifixion is painted in an illuminated letter, a simple cross is placed below for the votary to kiss instead of the picture, as it was found in practice, when only the picture was there, the tendency was to obliterate it by the recurrence of this form of devotion.

As an example of the influence of naturalism which had begun to make itself felt in art towards the end of the 15th century, we may cite The Romance of the Rose (Harl. MS. 4425), in the British Museum, which has two fine full-page miniatures with elaborate borderings, full of detail and colour, and which are also illustrative of costume. The text pages show the effect of double columns with small highly-finished miniatures (occupying the width of one column) interspersed. The style of work is akin to that of our next instance, the celebrated Grimani Breviary, now in the library of St. Mark's, Venice, the miniatures of which are said to have been painted by Memling. They are wonderfully rich in detail, and fine in workmanship, and are quite in the manner of the Flemish pictures of that period. We feel that the pictorial and illustrative power is gaining the ascendancy, and in its borders of highly wrought leaves, flowers, fruit, and insects, given in full relief with their cast shadows—wonderful as they are in themselves as pieces of work—it is evident to me, at least, that whatever graphic strength and richness of chiaro-oscuro is gained it is at the distinct cost of the beauty of pure decorative effect upon the page. After the delicate arabesques of the earlier time, these borders look a little heavy, and however great their pictorial or imitative merits, they fail to satisfy the conditions of a page decoration so satisfactorily.

Perhaps the most sumptuous examples of book decoration of this period are to be found in Italy, in the celebrated choir books in the cathedral of Siena. They show a rare union of imaginative form, pictorial skill, and decorative sense in the miniaturist, united with all the Italian richness and grace in the treatment of early Renaissance ornament, and in its adaptation to the decoration of the book page.

These miniatures are the work of Girolamo

da Cremona, and Liberale da Verona. At least, these two are described as "the most copious and indefatigable of the artists employed on the Corali." Payments were made to them for the work in 1468, and again in 1472-3, which fixes the date.

I am not ignoring the possibility of a certain division of labour in the illuminated MS. The work of the scribe, the illuminator, and the miniaturist are distinct enough, while equally important to the result. Mr. T. W. Broadley, who has compiled a Dictionary of Miniaturists, speaking of caligrapher, illuminator, and miniaturist, says:—"Each of these occupations is at times conjoined with either or both of the others," and when that is so, in giving the craftsman his title, he decides by the period of his work. For instance, from the 7th to the 10th centuries he would call him caligrapher; 11th to 15th centuries, illuminator; 15th to 16th centuries, miniaturist. Transcription he puts in another category as the work of the copyist scribe. But whatever division of labour there may or may not have been, there was no division in the harmony and unity of the effect. If in some cases the more purely ornamental parts, such as the floral borders and initials, were the work of one artist, the text of another, and the miniatures of another, all I can say is, that each worked together as brethren in unity, contributing to the beauty of a harmonious and organic whole; and if such division of labour can be ascertained to have been a fact, it goes to prove the importance of some co-operation in a work of art, and its magnificent possibilities.

The illuminated MS. books have this great distinction and advantage in respect of harmony of text and decoration, the text of the caligrapher always harmonising with the designs of the illuminator, it being in like manner all through the Middle Ages a thing of growth and development, acquiring new characteristics and undergoing processes of transformation less obvious perhaps, but not less actual, than the changes in the style and characters of the devices and inventions which accompanied it. The mere fact that every part of the work was due to the hand, that manual skill and dexterity alone has produced the whole, gives a distinction and a character to these MS. books which no press could possibly rival.

The difficulty which besets the modern book decorator, illustrator, or designer of printers' ornaments, of getting type which will harmonise properly with his designs, did not exist with the mediæval illuminator, who must always have been sure of balancing his designs by a body of text not only beautiful in the form of its individual letters, but beautiful and rich in the effect of its mass on the page, which was only enhanced when the initials were relieved with colour on gold, or beautiful pen work which grew out of them like the mistletoe from the solid oak stem.

The very pitch of perfection which penmanship, or the art of the caligrapher had reached in the 15th century, the calculated regularity and "purgation of superfluities" in the form of the letters, the squareness of their mass in the words, and approximation in length and height, seem to suggest and naturally lead up to the idea of the moveable type and the printed page.

Before, however, turning the next page of our subject, which I hope to treat of in my next lecture, let us take one more general and rapid glance at the MS. books from the point of view of design.

While examples of the two fields into which art may be said to be always more or less divided—the imitative and the inventive, or the illustrative and the decorative—are not altogether absent in the books of the Middle Ages, the main tendency and prevailing spirit is decidedly on the inventive and decorative side, more especially in the work of the illuminators from the 13th to the 15th centuries, and yet this inventive and decorative spirit is often allied with a dramatic and poetic feeling, as well as a sense of humour. We see how full of life is the ornament of the illuminator, how figures, birds, animals, and insects fill his arabesques, how he is often decorator, illustrator, and pictorial commentator in one.

Even apart from his enrichments, it is evident that the page was regarded by the caligrapher as a space to be decorated—that it should at least, regarded solely as a page of text, be a page of beautiful writing, the mass carefully placed upon the vellum, so as to afford convenient and ample margin especially beneath. The page of a book, in fact, may be regarded as a flat panel which may be variously spaced out. The caligrapher, the illuminator, and the miniaturist are the architects who planned out their vellum grounds and built beautiful structures of line and colour upon them for thought and fancy to dwell in. Sometimes the text is arranged in a single column as generally in the earlier MSS.;

sometimes in double, as generally in the Gothic and later MSS., and these square and oblong panels of close text are relieved by large and small initial letters sparkling in gold and colour, enclosed in their own framework, or escaping from it in free and varied branch work and foliation upon the margin, and set with miniatures like gems as in the "Bedford Missal," the larger initials increasing to such proportions as to enclose a more important miniature—a subject picture in short—a book illustration in the fullest sense, yet strictly a part of a general scheme of the ornamentation of the page.

Floral borders, which in some instances spread freely around the text and fill the margins, unconfined though not uninfluenced by rectangular lines or limits from a light and open, yet rich and delicate tracery of leaves and fanciful blossoms (as in the Bedford Missal); are in others framed in with firm lines (Tenison Psalter, p. 11); and in later 15th century MSS. with gold lines and mouldings, as the treatment of the page becomes more pictorial and solid in colour and relief. Sometimes the borders form a distinct framework, enclosing the text and dividing its columns, as in "The Book of Hours of René of Anjou" (Egerton MS. 1070), and the same design is sometimes repeated differently coloured. Gradually the miniaturist — the picture painter—although strictly and as formally decorative as the illuminator, at first asserts his independence, and influences the treatment of the border, which becomes a miniature also as in the Grimani Breviary, the Romance of the Rose, and the Choir Books of Sdena, until at last the miniature or the picture is in danger of being more thought of than the book, and we get books of framed pictures instead of pictured or decorated books. In the Grimani Breviary the miniature frequently occupies the whole page with a single subject-picture; or the miniature is superimposed upon a pictured border, which, strengthened by rigid architectural lines and tabernacle work, form a rich frame.

All these varieties we have been examining are, however, interesting and beautiful in their own way in their results. In considering any form of art of a period which shows active traditions, real life and movement, natural growth and development, we are fascinated by its organic quality, and though we may detect the absorption or adaptation of new elements, and new influences from time to time leading to changes of style and structure of design, as well as changed temper and feeling, as long as this natural evolution continues, each variety has its own charm and its own compensations; while we may have our preferences as to which approaches most nearly to the ideal of perfect adaptability, and, therefore, of decorative beauty.

In the progressive unfolding which characterises a living style, all its stages must be interesting and possess their own significance, since all fall into their places in the great and golden record of the history of art itself.

Miscellaneous.

NEW SOUTH AFRICAN TRADING COMPANY.

It was announced some months ago that steps were being taken to obtain a charter for a company which would embrace in its operations the immense area lying between the Lower and Central Zambesi on the north, and the Transvaal border on the south. The new British South African Company, as it is called, will begin immediately to work on much the same lines as those of the Imperial British East Africa Company. The "body politic and corporate" in whose names the charter has been drawn are the Duke of Abercorn, the Duke of Fife, Lord Gifford, Cecil John Rhodes, Albert Henry George Grey, and George Cawston.

The principal field of operations, according to the proposed charter, will be the region of South Africa lying immediately to the north of British Bechuanaland, and to the north and west of the South African Republic (the Transvaal), and to the west of the Portuguese dominions. No western limit is stated. The company is empowered to govern the territories embraced in its charter in the name and in behalf of the interests of the British Empire. Thus, therefore, it is stipulated that the company must always remain British in its directorate, composition, and domicile, and that no director shall be appointed without the approval of "our Secretary of State." The company is empowered to abolish by degrees "any system of slave-trade or domestic servitude in the territories aforesaid;" and to regulate the traffic in intoxicating liquors in such a way as to prevent their sale to the natives.

With regard to finance, the British South African Company, like the British East Africa Company, is enjoined to furnish annually to the Government accounts of its expenditure for administrative purposes, and all sums received by it by way of public revenue, as distinguished from its commercial profits, together with a report as to its public proceedings and the condition of the territories within its sphere of operations. The company must pay due respect to

any requirements or suggestions of her Majesty's High Commissioner and other imperial officers in South Africa. It may have its own flag, but that flag must indicate the distinctively British character of the company. No monopoly of trade will be allowed, though concessions may be granted for public works, and precautions may be taken for the preservation of elephants and other game. Due observance must be had to imperial obligations to other States. The company must appoint all necessary officers, and establish courts for the administration of justice. As to the share capital of the company, that is set down at a million sterling, in one pound shares. This capital the company is authorised to increase as it may deem necessary, to borrow money by debenture or otherwise, and to establish banks and other associations.

Within a year the company is bound to execute a deed of settlement for the more effective carrying out of the various purposes mentioned in the proposed charter, for the division and distribution of profits, the audit of accounts, and other matters of detail. Meantime, the persons already named will act as directors of the company; while, under any circumstances, the Duke of Fife, the Duke of Abercorn, and Mr. Albert Grey will remain permanent directors. The present charter is to subsist for twenty-five years, at the end of which, and at the end of every succeeding ten years, the Crown may revise or repeal so much of the charter as relates to administrative and public affairs—that is, the Crown reserves the right to take over these territories and administer them directly as colonial possessions of the United Kingdom.

Correspondence.

CANTOR LECTURES ON INSTRUMENTS FOR MEASURING RADIANT HEAT.

I wish to explain the fifth equation in my fourth lecture, which appears in the *Journal* of October 11, (p. 855).

It would appear from this that the sensibility of the instrument would be increased by diminishing the period of oscillation, owing apparently to the stronger field that could then be employed. The fact is that the term sensibility was used in a special sense in the paper from which this formula was quoted, and I forgot that this was the case. The expression should be multiplied by τ^2, when it becomes—

$$S = \sqrt{\frac{\pi \tau^3}{KC}}$$

I may perhaps also correct the second equation, on page 184 in the paper referred to, which shows what difference of temperature would produce any required deflection of a circuit of the greatest efficacy in a field which is just sufficient to make the motion dead beat. This should be multiplied by the factor $\sqrt{\frac{\pi}{\tau}}$. It then becomes—

$$\text{Temperature difference} = \frac{16}{3}\frac{\alpha'}{\theta}\sqrt{\frac{\pi^3}{\tau^3}}\sqrt{(KC)}$$

Where α' is the angle of deflection, θ the thermo-electric power, and the other quantities are as before.

If α' is supposed to be $\frac{1}{10000}$, that is a deflection of $\frac{1}{5}$ mm. on a scale at a distance of one meter, if θ is 10,000, which is certainly too low a value, and τ is 10 seconds, then the temperature difference that would be necessary to produce the deflection α would be $5 \cdot 52 \times 10^{-7}$ degrees Centigrade. If it is supposed that the magnetic field is made four times as strong as that which just makes the motion dead beat, then the best circuit must be reduced in area until the motion is again just dead beat; the sensibility will then be $(2 - \frac{1}{4})$ times as great, or the difference of temperature necessary to produce any deflection will be $(2 - \frac{1}{4})$ times as small, so that $2 \cdot 58 \times 10^{-7}$ degrees will produce the deflection supposed. Thus about a four-millionth of a degree should produce a deflection of one-fifth of a millimetre, or one-millionth of a degree of nearly one millimetre.

As the value 10,000, assigned to θ, is about that of antimony and bismuth, and the alloys are one-third greater, it is probable that an instrument as well made as possible would, with a period of ten seconds, give a deflection of one millimetre for every millionth of a degree, by which the lower ends of the bars are heated above the upper ends.

C. V. BOYS.

Obituary.

DR. JOULE, F.R.S. — James Prescott Joule, LL.D., D.C.L., the discoverer of the law of the mechanical equivalent of heat, died at Sale, near Manchester, on Friday night, 11th inst., after many years of feeble health. Dr. Joule was born at Salford, December 24, 1818, and in his early youth he studied chemistry under the great chemist Dalton. In 1841 and 1842 he was working at the subject which is so indissolubly associated with his name, and in 1843 the earliest form of his great discovery was announced in a paper on "The Calorific Effects of Magneto-Electricity, and on the Mechanical Value of Heat," read at the Cork meeting of the British Association. In 1850 he received the Royal medal of the Royal Society, and in 1870 the Copley medal of the same society. He was author of a large number of papers, published in journals and transactions, and a complete collection of these papers has been published by the Physical Society. In 1880 the Society of Arts awarded the Albert medal to Dr. Joule "for having established, after most laborious research, the true relation between heat, electricity, and mechanical work, thus affording to the engineer a sure guide in the application of science and industrial pursuits."

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All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

Proceedings of the Society.

CANTOR LECTURES.

THE DECORATION AND ILLUSTRATION OF BOOKS.

By Walter Crane.

Lecture II.—Delivered March 11th, 1889.

We have seen to what a pitch of perfection and magnificence the decoration and illustration of books attained during the Middle Ages, and the splendid results to which art in the three applied forms—caligraphy, illumination, and miniature—contributed. We have traced a gradual progression and evolution of style through the period of MS. books, both in the development of writing and ornament. We have noted how the former became more and more regular and compact in its mass on the page, and how in the latter the illustrative or pictorial side grew more and more important, until at the close of the 15th century we had large and elaborately drawn and naturalistic pictures framed in the initial letters, as in the Choir books of Siena, or occupying the whole page with a single subject, as in the Grimani Breviary. The tree of design, springing from small and obscure germs, sends up a strong stem, branches and buds in the favourable sun, and finally breaks into a beautiful free efflorescence and fruitage. Then we mark a fresh change. The autumn comes after the summertide, winter follows autumn, till the new life, ever ready to spring from the husk of the old, puts forth its leaves, until by almost imperceptible degrees and changes, and the silent growth of new forces, the face of the world is changed for us.

So it was with the change that came upon European art towards the end of the 15th century, the result of many causes working together; but as regards art as applied to books, the greatest of these was of course the invention and application of printing. Like most great movements in art or life, it had an obscure beginning. Its parentage might be sought in the woodcuts of the earlier part of the 15th century applied to the printing of cards. The immediate forerunners of printed books were the block books. Characteristic specimens of the quaint works may be seen displayed in the King's Library, British Museum, from which I give some selections in the lantern. The art of these block books is quite rude and primitive, and, contrasted with the highly-finished work of the illuminated MS. of the same time, might almost belong to another period. These are first tottering steps of the infant craft; the first faint utterances, soon to grow into strong, clear, and perfect speech, to rule the world of books and men.

Germany had not taken any especial or distinguished part in the production of MSS. remarkable for artistic beauty or original treatment; but her time was to come, and now, in the use of an artistic application of the invention of printing, and the new era of book decoration and illustration, she at once took the lead. Seeing that the invention itself is ascribed to one of her own sons, it seems appropriate enough, and natural that printing should grow to quick perfection in the land of its birth; so that we find some of the earliest and geatest triumphs of the Press coming from German printers, such as Gutenburg, Fust, and Schœffer, not to speak yet of the wonderful fertility of decorative invention, graphic force, and dramatic power of German designers, culminating in the supreme genius of Albert Durer and Hans Holbein.

1455 appears to be the earliest definite date that can be fixed on to mark the earliest use of printing. To this date is assigned the issue of the famous Mazarin Bible, from the press of Gutenburg and Fust at Mentz. My slide is taken from the copy in the British Museum. Mr. Bullen says, "The copy which first attracted notice in modern times was discovered in the library of Cardinal Mazarin"—hence the name.

It is noticeable as showing how transitional was the change in the treatment of the page. The scribe has been supplanted—the mar-

shalled legions of printed letters have invaded his territory, and driven him from his occupation; but the margin is still left for the illuminator to spread his coloured borders upon, and the initial letters wait for the touch of colour from his hand. The early printers evidently regarded their art as providing a substitute for the MS. book. They aimed at doing the work of the scribe, and doing it better and more expeditiously. No idea of a new departure in effect seems to have been entertained at first, to judge from such specimens as these.

Another early printed book is the Mentz Psalter. It is printed on vellum, and comes from the press of Fust and Schœffer in 1457. It is remarkable not only as the first printed psalter and as the first book printed with a date, but also as being the first example of printing in colours. The initial letter B is the result of this method, and it affords a wonderful instance of true register. The blue of the letter fitted cleanly into the red of the surrounding ornament with a precision which puzzles our modern printers, and it is difficult to understand how such perfection could have been attained. Mr. Emery Walker has suggested to me that the blue letter itself might have been cut out, inked, and dropped in from the back of the red block when that was in the press, and so the two colours printed together. If this could be done with sufficient precision, it would certainly account for the exactitude of the register. Apart from this interesting technical question, however, the page is a very beautiful one, and the initial, with its solid shape of figured blue, enclosed in the delicate red pen-like tracery climbing up and down the margin, is a charming piece of page decoration. The original may be seen in one of the cases in the King's Library, British Museum. We have here an instance of the printer aiming at directly imitating and supplanting by his craft the art of the caligrapher and illuminator, and with such a beauty and perfection of workmanship as must have astonished them, and given them far more reason to regard the printer as a dangerous rival than had (as it is said) the early wood engravers, who were unwilling to help the printer by their art for fear his craft would injure their own, which seems somewhat extraordinary considering how closely allied both wood engraver and printer have been ever since. The example of the Mentz Psalter does not seem to have been much followed, and as regards the application of colour, it was as a rule left as a matter of course to be added by the miniaturist, who evidently declined as an artist after he had got into the way of having his designs in outline provided for him ready-made by the printer; or, rather, perhaps the accomplished miniature printer, having carried his art as applied to books about as far as it would go, became absorbed as a painter of independent pictures, and the printing of books fell into inferior hands. There can be no doubt that the devices and decorations of the early printers were intended to be coloured in emulation of illuminated and miniatured MSS., and were regarded, in fact, as the pen outlines of the illuminator, only complete when filled in with colours and gold. It appears to have been only by degrees that the rich and vigorous lines of the woodcut, as well as the black and white effect, became admired for their own sake—so slowly moves the world!

Perhaps the most interesting examples of the use of early printing as a substitute for illumination and miniature are to be found in the Books of Hours which were produced at Paris in the later years of the 15th and the early years of the 16th centuries (1487-1519 about) by Philip Pigouchet, Verrard, Kerver, De Brie, and Hardouyn.

I have obtained some slides from copies in the Art Library at South Kensington Museum. The originals are printed on vellum.*

The effect of the richly designed borders on black dotted grounds is very pleasant, but these books seem to have been intended to be illuminated and coloured. We find in some copies that the full page printed pictures are coloured, being worked up as miniatures, and the semi-architectural borderings with Renaissance mouldings and details are gilded flat, and treated as the frame of the picture. Here is one which has the mark of the printer, Gillet Hardouyn (G. H. on the shield), on the front page. In another copy (1515) this is printed and the framework gilded; the subject is Nessus the centaur carrying off Dejanira, the wife of Hercules; a sign of the tendency to revive classical mythology which had set in,

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* Books of Hours "contained the canonised Hours of Prayers to be observed every day, originally recommended to all the faithful, afterwards imposed as indispensable upon the ministers and servants of churches, and congregations of monks. At first"—I am quoting from Mr. Quaritch's treatise on Liturgical Literature—"only the hours from sunrise to sunset were comprised as hours of prayer; but before long the whole course of the twenty-four hours was included and divided into spaces of three hours each, during which the service appointed to the time might be performed."

in this case, in curious association with a Christian service-book. It is noticeable how soon the facility for repetition by the press was taken advantage of, and a design, especially if on ornamental borderings of a page, often repeated several times throughout a book. These borderings and ornaments being generally in separate blocks as to headings, side panels, and tail pieces, could easily be shifted and a certain variety obtained by being differently made up. Here we may see commercialism creeping in. Considerations of profit and economy no doubt have their effect, and mechanical invention comes in to cheapen not only labour, but artistic invention also.

It took some time, however, to turn the printer into the manufacturer or tradesman pure and simple. Nothing is more striking than the high artistic character of the early printed books. The invention of printing, coming as it did when the illuminated MSS. had reached the period of its greatest glory and perfection, with the artistic traditions of fifteen centuries poured, as it were, into its lap, filling its founts with beautiful lettering, and guiding the pencil of its designers with a still unbroken sense of fitness and perfect adaptability; while as yet the influence of the revival of classic learning and mythology was only felt as the stirring and stimulating breath of new awakening spring—the aroma of spice-laden winds from unknown shores of romance—or as the mystery and wonder of discovery, standing on the brink of a half-disclosed new world, and fired with the thought of its possibilities—as when

> "Stout Cortez stared, with all his men,
> Silent upon a peak in Darien."

Had the discovery of printing occurred two or three centuries earlier, it would have been curious to see the results. But after all, an invention never lives until the world is ready to adopt it. It is impossible to say how many inventions are new inventions. "Ask and ye shall have," or the practical application of it, is the history of civilisation. Necessity, the stern mother, compels her children to provide for their own physical and intellectual necessities, and in due time the hour and the man (with his invention) arrives.

Classical mythology and Gothic mysticism and romance met together in the art and books of the early Renaissance. Ascetic aspiration strives with frank paganism and nature worship. The gods of ancient Greece and Rome seemed to awake after an enchanted sleep of ages, and appear again unto men.

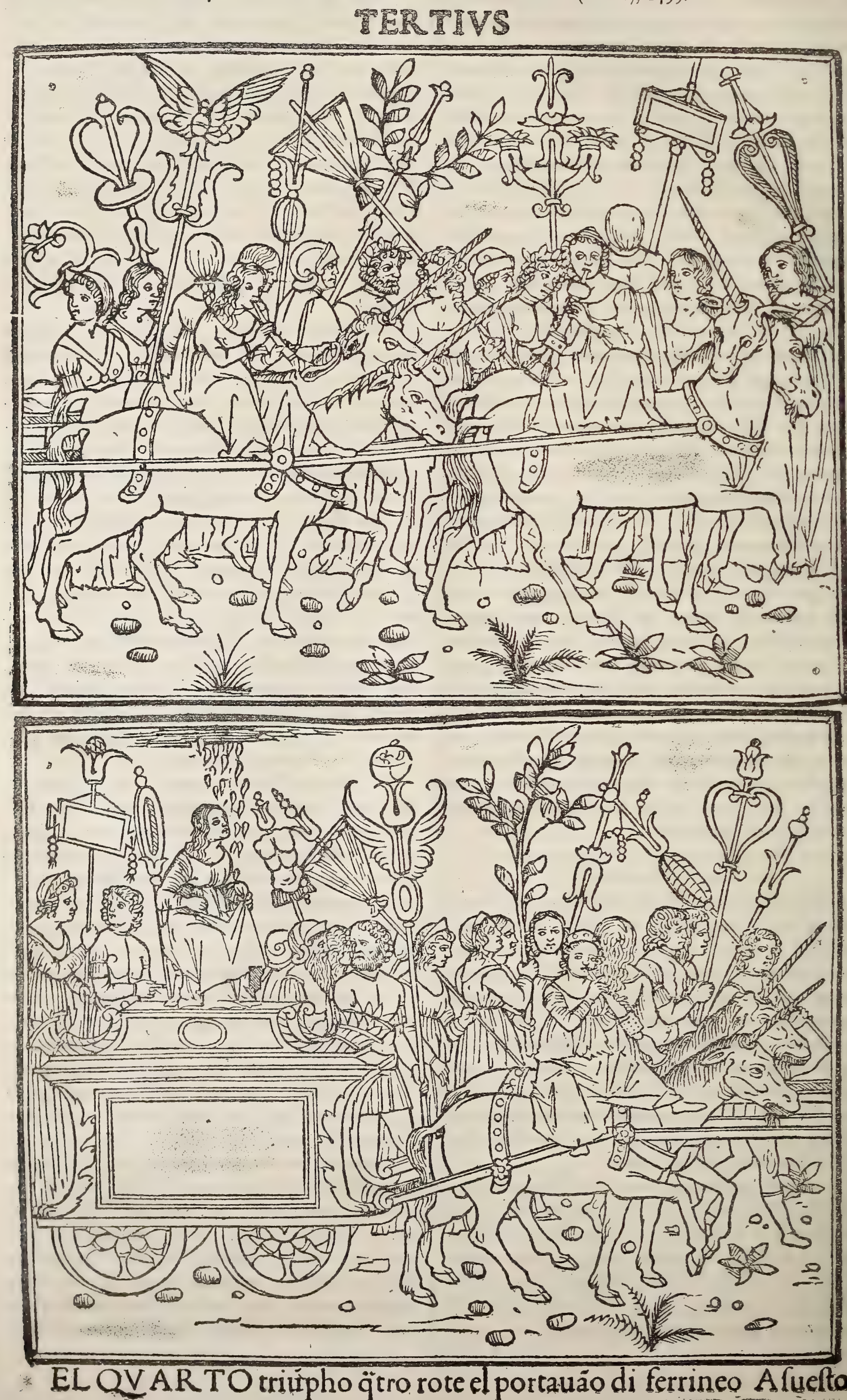
Italy, having hardly herself ever broken with the ancient traditions of Classical art and religion, became the focus of the new light, and her independent republics, such as Florence and Venice, the centres of wealth, culture, refinement, and artistic invention. Turkish conquest, too, had its effect on the development of the new movement by driving Greek scholars and the knowledge of the classical writers of antiquity Westward. These were all materials for an exceptional development of art, and, above all, of the art of the printer, and the decoration and illustration of books.

The name of Aldus, of Venice, is famous among those of the early Renaissance printers. Perhaps the most remarkable book, from this or any press, for the beauty of its decorative illustration, is the *Poliphili Hypnerotomachia* — "The Dream of Poliphilus"—printed in 1499, an allegorical romance of love in the manner of those days. The authorship of the design has been the subject of much speculation. I believe they were attributed at one time to Mantegna, but they are now generally ascribed to one of the Bellini. The style of the designer—the quality of the outline, the simplicity yet richness of the designs, their poetic feeling, the mysticism of some, and frank paganism of others, places the series quite by themselves. The first edition is now very difficult to obtain, and might cost something like 100 guineas.

My illustrations are taken from the copy in the Art Library at South Kensington Museum, and are from negatives taken by Mr. Griggs, for the Science and Art Department, who are about to issue a set of reproductions in photo-lithography, by him, of the whole of the wood-cuts in the volume of the original size, at the price, I believe, of 5s. 6d. Here is an instance of what photographic reproduction can do for us—when originals of great works are costly or unattainable we can get reproductions for a few shillings, for all practical purposes as good for study as the originals themselves. If we cannot, in this age, produce great originals, we can at least reproduce them—perhaps the next best thing.

There is a French edition of Poliphilus printed at Paris, by Kerver, in 1561, which has a frontispiece designed by Jean Goujon, or rather, Jean Cousin. The illustrations, too, have all been redrawn, and are treated in quite a different manner from the Venetian originals—but they have a character of their own, though of a later, florid, and more self-

FIG. 7.—POLIPHILI HYPNEROTOMACHIA. *Venice* (*Aldus*), 1499.



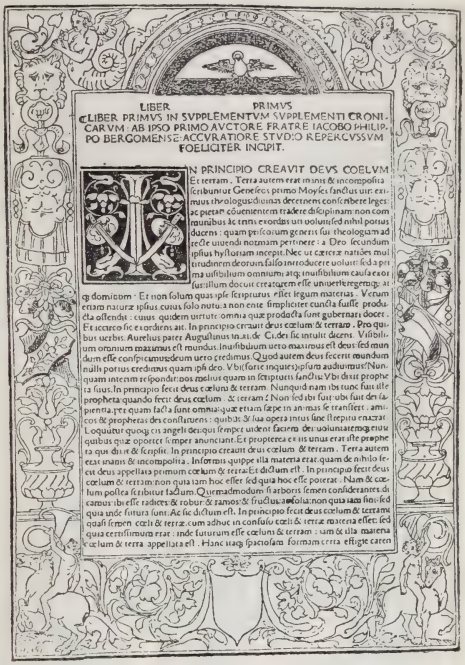
conscious type, as might be expected from Paris in the latter half of the 16th century. The initial letters of a series of chapters in the book spell, if read consecutively, Francisco Columna (F.R.A.N.C.I.S.C.O. C.O.L.V.M.N.A.)—the name of the writer of the romance.

Mr. Walker has lent me a slide giving an initialed page of type from the first edition. Whether such designs as these were intended to be coloured is doubtful. They are very satisfactory as they are in outline, and want nothing else. The book may be considered as an illustrated one, drawings of monuments, fountains, standards, emblems, and devices are placed here and there in the text, but they are so charmingly designed and drawn that the effect is decorative, and being in open line the mechanical conditions are perfectly fulfilled of surface printing with the type.

After the beautiful productions of the German, Italian (of which some reproductions are given here), and French printers, our own William Caxton's first books seem rather rough, though not without character and, at any rate, picturesqueness, if they cannot be quoted as very accomplished examples of the printer's art. The first book printed in England is said to be Caxton's "Dictes and Sayings of the Philosophers," printed by him at Westminster in 1477.

A noticeable characteristic of the early printed books is the development of the title page. Whereas the MSS. generally did without one, with the advent of printing the title page became more and more important, and even if there were no other illustrations or ornaments in a book, there was often a woodcut title. Such examples as some of these just shown in the lantern give a good idea of what charming decorative feeling these title page designs sometimes displayed, and those greatest of designers and book decorators and illustrators, Albert Durer and Hans Holbein, showed their power and decorative skill, and sense of the resources of the woodcut, in the designs made by them for various title pages.

There is a fine title page designed by Holbein, printed by Petri, at Basle, in 1542. It was originally designed and used for an edition of the New Testament, printed by the same Adam Petri in 1523. At the four corners are the symbols of the Evangelists; the arms of the city of Basle are in the centre of the upper border, and the printer's device occupies a corresponding space below. Figures of SS. Peter and Paul are in niches at each side. But


LIBER PRIMVS

LIBER PRIMVS IN SVPPLEMENTVM SVPPLEMENTI CRONICARVM: AB IPSO PRIMO AVCTORE FRATRE IACOBO PHILIPPO BERGOMENSE: ACCVRATIORE STVDIO REPERCVSSVM FOELICITER INCIPIT.

IN PRINCIPIO CREAVIT DEVS COELVM Et terram. Terra autem erat inanis & incomposita scribuntur Geneseos primo Moyses sanctus vir: eximius theologus: divinas decernens conscribere leges: ac pietati convenientem tradere disciplinam: non communibus ac tritis exordiis uti voluit: sed nihil potius ducens: quam priscorum generis sui theologiam ad recte vivendi normam pertinere: a Deo secundum ipsius hystoriam incepit. Nec ut caeterae natiões multitudinem deorum falso introducere voluit: sed a prima visibilium omnium: atque invisibilium causa exorsus: illum docuit creatorem esse universi regemque atque dominum. Et non solum quas ipse scripturus esset legum materias. Verum etiam naturae ipsius, cuius solo nutu: a non ente simpliciter cuncta fuisse producta ostendit: cuius quidem virtute: omnia quae producta sunt gubernari docet. Et iccirco sic exordiens ait. In principio creavit deus coelum: & terram. Pro quibus verbis. Aurelius pater Augustinus in xi. de Ci. dei sic intulit dicens. Visibilium omnium maximus est mundus. Invisibilium vero maximus est deus: sed mundum esse conspicimus: deum vero credimus. Quod autem deus fecerit mundum nulli potius credimus quam ipsi deo. Ubi (forte inquies) ipsum audivimus? Nunquam interim respondit: nos melius quam in scripturis sanctis: Ubi dixit propheta suus. In principio fecit deus coelum & terram. Nunquid nam ibi tunc fuit ille propheta quando fecit deus coelum. & terram? Non sed ibi fuit: ubi fuit dei sapientia, per quam facta sunt omnia: quae etiam saepe in animas se transfert: amicos & prophetas dei constituens: quibus & sua opera intus sine strepitu enarrat. Loquuntur quoque eis angeli dei: qui semper vident faciem dei: voluntatemque eius: quibus quae oportet semper anunciant. Et propterea ex iis unus erat iste propheta qui dixit & scripsit. In principio creavit deus coelum & terram. Terra autem erat inanis & incomposita. Informis quippe illa materia erat, quam de nihilo fecit deus appellata primum coelum & terra: Et dictum est. In principio fecit deus coelum & terram: non quia iam hoc esset sed quia hoc esse poterat. Nam & coelum postea scribitur factum. Quemadmodum si arboris semen considerantes dicamus: ibi esse radices: & robur: & ramos: & fructus: & folia: non quia iam sint: sed quia inde futura sunt: Ac sic dictum est. In principio fecit deus coelum & terram quasi semen coeli & terrae, cum adhuc in confuso coeli & terrae materia esset: sed quia certissimum erat: inde futurum esse coelum & terram: iam & illa materia coelum & terra appellata est. Hanc itaque spaciosam formam certa effigie caren

FIG 8.—SUPPLIMENTUM SUPPLIMENTI. *Venice: Gregorius*, 1506.

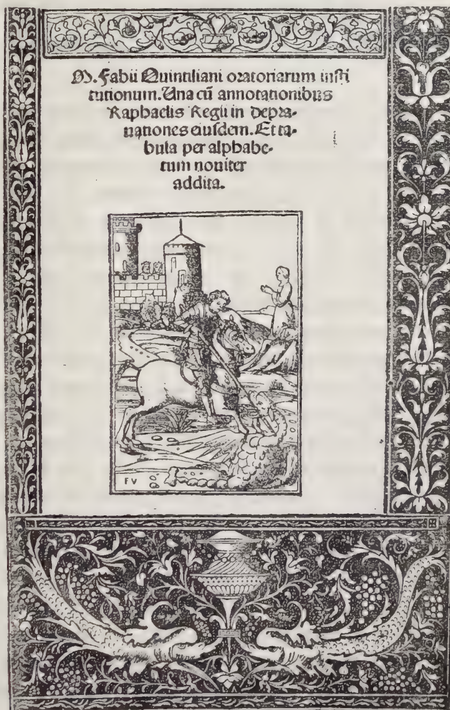


FIG. 9.—ORATIONS OF QUINTILIAN. *Venice: Gregorius de Rusconibus*, 1512.

Fig. 10.—Amica Veritas de Bernardino Corio. *Milan: Aless. Minattano,* 1506.

the work always most associated with the name of Holbein is the remarkable little book containing the series of designs known as the "Dance of Death," the first edition of which was printed at Lyons in 1538. I give two slides photographed from this edition—two remarkable designs in a wonderful series. These cuts are only about 2½ by 2 inches, and yet an extraordinary amount of invention, graphic power, dramatic and tragic force, and grim and satiric humour, is compressed into them. They stand quite alone in the history of art, and give a wonderfully interesting and complete series of illustrations of the life of the 16th century. Holbein is supposed to have painted this "Dance of Death" in the palace of Henry the VIII., erected by Cardinal Wolsey at Whitehall, life size; but this was destroyed in the fire which consumed nearly the whole of that palace in 1697.

It is interesting to note that Holbein's father and grandfather both practised engraving and painting at Augsburg. Hans Holbein the elder married a daughter of the elder Burgmair, father of the famous Hans Burgmair.

The noble designs of the master craftsman of Nuremburg, Albert Durer, are well known. His extraordinary vigour of drawing, and sense of its resources as applied to the woodcut, made him a great force in the decoration and illustration of books, and many are the splendid designs from his hand. Here is a well known and beautiful specimen from his famous series of "The Life of the Virgin," printed by him at Nuremberg, in 1511, when he was at the height of his powers.

Albert Durer and Holbein, indeed, seem to express and to sum up all the vigour and power of design of that very vigorous and fruitful time of the German Renaissance. They had able contemporaries,* of course, and they themselves, like all great masters in art, were the result of long traditions, and constant and close practice, depending on what had gone before them, as well as on the conditions of their time, which opened such a field for the development of their powers in this particular direction of designs for printed books.

The various marks adopted by the printers themselves are often decorative devices of great interest and beauty. The French printers, Gillett Hardouyn and Thielman Kerver, for instance, had charming devices with which they generally occupied the front page of their Books of Hours. Others were pictorial puns and embodied the name of the printer under some figure, such as that of Petrus of Basle, who adopted a device of a stone, which the flames and the hammer stroke failed to destroy; or the mark of Philip le Noir—a black shield with a negro crest and supporter; or the palm tree of Palma Isingrin. Others were purely emblematic and heraldic, such as the dolphin twined round the anchor, of Aldus, with the motto "*Propera tarde*"—"hasten slowly." This, and another device of a crab holding a butterfly by its wings, with the same signification, are both borrowed from the favourite devices of two of the early emperors of Rome—Augustus and Titus. This symbolic, emblematic, allegorising tendency which had been more or less characteristic of both art and literature, in various degrees, from the most ancient times, became more systematic-

* Among whom, Lucas Cranach (the elder) born 1470; Hans Burgmir, who is associated with Albert Durer in the work of the celebrated series of woodcuts, "The Triumphs of Maximilian;" Jost Amman; and Han Sebald Betham, may be mentioned.

ally cultivated, and collections of them began to appear in book form in the 16th century. The earliest being that of Alciati, the first edition of whose book appeared in 1522, edition after edition following each other from various printers and places from that date to 1621, with ever-increasing additions, and being translated into French, German, and Italian. Mr. Henry Green, the author of "Shakespeare and the Emblem Writers" (written to prove Shakespeare's acquaintance with the emblem books, and constant allusions to emblems), said of Alciati's book that "it established, if it did not introduce, a new style for emblem literature—the classical, in the place of the simply grotesque and humorous, or of the heraldic and mystic."

There is an edition of Alciati printed at Lyons (Bonhomme) 1551, a reprint of which was published by the Holbein Society in 1881. The figure designs and the square woodcut subjects are supposed to be the work of Solomon Bernard—called the little Bernard—born at Lyons in 1522. These are surrounded by elaborate and rather heavy decorative borders, in the style of the later Renaissance, by another hand, some of them bearing the monogram P.V., which has been explained to mean either Picrino del Vega, or Petro De Vingles, a printer of Lyons.

These borders, as we learn from a preface to one of the editions ("Ad Lectorem"—Roville's Latin text of the emblems), were intended as patterns for various craftsmen. "For I say this is their use, that as often as any one may wish to assign fulness to empty things, ornament to base things, speech to dumb things, and reason to senseless things, he may, from a little book of emblems, as from an excellently well-prepared hand-book, have what he may be able to impress on the walls of houses, on windows of glass, on tapestry, on hangings, on tablets, vases, ensigns, seals, garments, the table, the couch, the arms, the sword, and lastly, furniture of every kind."

An emblem has been defined ("Cotgrave's Dictionary," Art. "Emblema") as "a picture and short posie, expressing some particular conceit;" and by Francis Quarles as "but a silent parable;" and Bacon, in his "Advancement of Learning," says:—"Embleme deduceth conceptions intellectuall to images sensible, and that which is sensible more fully strikes the memory, and is more easily imprinted than that which is intellectual."

All was fish that fell into the net of the emblem writer or deviser; hieroglyphic, heraldry, fable, mythology, the ancient Egyptians, Homer, ancient Greece and Rome, Christianity, or pagan philosophy, all in their turn served

"To point a moral and adorn a tale."

As to the artistic quality of the designs which are found in these books, they are of very various quality, those of the earlier 16th century with woodcuts being naturally the best and most vigorous, corresponding in character to the qualities of the contemporary design. Holbein's "Dance of Death," or rather "Images and Epigrams of Death," as he calls it, might be called an emblem book, but very few can approach it in artistic quality. Some of the devices in early editions of the emblem books of Giovio, Witney, and Quarles have a certain quaintness, but though such books necessarily depended on their illustrations, the moral and philosophic, or epigrammatic burden proved in the end more than the design could carry, when the vigorous impulse which characterised the early Renaissance had declined, and design, as applied to books, became smothered with classical affectation and pomposity, and the clear and vigorous woodcut was supplanted by the doubtful advantage of the copper-plate. The introduction of the use of the copper-plate marks a new era in book illustration, but as regards their decoration, one of distinct decline. While the surface-printed block, whether woodcut or metal engraving (by which method many of the early book illustrations were rendered), accorded well with the conditions of the letter-press printing, as they were set up with the type and printed by the same pressure in the same press. With copper-plate quite other conditions came in, as the paper has to be pressed into the etched or engraved lines of the plate, instead of being impressed by the lines in relief of the wood or the metal. Thus, with the use of copper-plate illustrations in printed books, that mechanical relation which exists between a surface-printed block and the letter-press was at once broken, as a different method of printing had to be used. The apparent, but often specious, refinement of the copper-plate did not necessarily mean extra power or refinement of draughtsmanship or design, but merely thinner lines, and these were often attained at the cost of richness and vigour, as well as decorative effect.

The first book illustrated with copper-plate engravings, however, bears an early date—1477. ["El Monte Sancto di Dio." Niccolo

di Lorenzo, Florence.] In this case it was reserved for the full page pictures. The method does not seem to have commended itself much to the book designers, and did not come into general use until the end of the 16th century, with the decline of design.

Before we conclude our series of illustrations, I should like to show some specimens of what might be called purely illustrative work, while the 16th century was still in its prime. The encyclopædic books of this period—the curious compendiums of the knowledge of those days—were full of entertaining woodcuts, diagrams, and devices, and the various treatises on grammar, arithmetic, geometry, physiology, anatomy, astronomy, geography, were made attractive by them, each section preceded perhaps by an allegorical figure of the art or science discoursed of in the costume of a grand dame of the period. The herbals and treatises on animals were often filled with fine floral designs and vigorous, if sometimes half-mythical, representations of animals.

Here are some examples from a beautiful herbal ("Fuschius : De Historia Stirpium Basle," Isingrin, 1542) belonging to Mr. William Morris, who has allowed me to take these illustrations from his copy. They are not only faithful and characteristic as drawings of the plants themselves, but are beautiful as decorative designs, being drawn in a fine free style, and with a delicate sense of line, and well thrown upon the page. At the beginning of the book is a woodcut portrait of the author, Leonard Fusch—possibly the fuschia may have been named after him—and at the end is another woodcut giving the portraits of the artist, the designer of the flowers, and the draughtsman on wood and the formscnieder, or engraver on wood, beneath. The first two are busy at work, and it will be noticed the artist is drawing from the flower itself with the point of a brush, the brush being fixed in a quill in the manner of our water-colour brushes. The draughtsman holds the design or paper while he copies it upon the block. The portraits are vigorously drawn in a style suggestive of Hans Burgmir.

As examples of design in animals, here are some vigorous woodcuts from a "History of Quadrupeds," by Conrad Gesner, printed by Froshow, of Zurich, in 1554. The porcupine is as like a porcupine as need be, and there can be no mistake about his quills. The drawings of birds are excellent, and one of a crane (as I ought, perhaps, more particularly to know) is very characteristic.

But we have passed the Rubicon—the middle of the 16th century. Ripening so rapidly, and blossoming into such excellence and perfection as did the art of the printer, and design as applied to the printed page, through the woodcut and the press, their artistic character and beauty was somewhat short-lived. Up to about this date (1554 was the date of our last example), as we have seen, to judge only from the slides I have put before you, what beautiful books were printed, remarkable both for their decorative and illustrative value, and often uniting these two functions in perfect harmony; but after the middle of the 16th century both vigour and beauty in design generally may be said to have declined. Whether the world had begun to be interested in other things—and we know the great discovery of Columbus had made it practically larger—whether discovery, conquest, and commerce more and more filled the view of the foremost spirits, and art was only valued as it illustrated or contributed to the knowledge of or furtherance of these; whether the Reformation or the spirit of Protestantism, turning men's minds from outward to inward things, and in its revolt against the half paganised Catholic Church, involving a certain ascetic scorn and contempt for any form of art which did not serve a direct moral purpose, and which appealed to the senses rather than to the emotions or the intellect, practically discouraged it altogether. Whether that new impulse given to the imagination by the influence of the revival of Classical learning, poetry, and antique art, had become jaded, and, while breaking with the traditions and spirit of Gothic or Mediæval art, began to put on the fetters of authority and pedantry, and so, gradually overlaid by the forms and cerements of a dead style, lost its vigour and vitality. Whether due to one or all of these causes, certain it is that the lamp of design began to fail, and, compared with its earlier radiance, shed but a doubtful flicker upon the page through the succeeding centuries.

Miscellaneous.

AGRICULTURAL AND INDUSTRIAL PRODUCTS OF TURKEY.

The *Journal de la Chambre de Commerce de Constantinople* says that frequent inquiries have been addressed to it from abroad respecting the agricultural and industrial products of the Ottoman Empire,

and in reply, a statement upon the subject has been prepared, of which the following is a *resumé*. On all points of the *vilayet* of Hudavendighiar the cultivation of cereals is carried on on a large scale. Sericulture is also in a flourishing condition, and the silks produced in the district are largely exported. The rose trees of Kezanlik imported some few years ago have been a great success, and essence and rose-water has been prepared of almost as good a quality as that produced in Kezanlik itself. The vine is found in many parts of the Empire, and is cultivated very extensively at Mont Athos, the Dardanelles, Tenedos, Chio, and Smyrna. The cultivation of opium is carried on in the greater part of the Empire, and is particularly prosperous in the *sandjak* of Malatia. Dyeing materials, such as indigo, cochineal, &c., are found in the *vilayets* of Syria and Aïdin, and it is desired to extend their cultivation in the interior of Anatolia. The provinces and *sandjaks* which, independently of cereals, produce cotton for local consumption as well as for export, are Smyrna, Magnesia, Adana, Aleppo, Demas, Nablour, Mossoul, and Bassorah. Cotton is also cultivated in the interior of Anatolia, and in the greater part of the *vilayet* of Maamurat-ul-Aziz. The rearing of bees and silkworms is carried on to a very large extent in Turkey. The principal *vilayets* in which these industries are practised are those of Hudavendighiar, Adrianople, Aïdin, Koniah, and Diarbékir. Carpets known as *sédjadés* and *kilims*, and other similar tissues, are manufactured in the province of Aïdin, and enter into competition with similar articles produced in Europe. The cultivation of cereals is also carried on on a large scale in the *vilayets*, while the figs, grapes, dates, olives, tobacco, opium, gall-nuts, silks, woollens, and essence of roses of this province are well known throughout Europe. At one period various stuffs manufactured at Aleppo, such as *zerbaf*, *ergherié*, velvets, &c., were much appreciated in various parts of Europe, and thirty years ago there were still 40,000 looms in the province. The stuffs woven there had a high reputation, not only in Turkey, but throughout Europe. At the present time there are only very few looms existing. At Diarbékir, stuffs for wearing apparel are produced which, known under the of *pétie*, comprise a species of fine cloth (*burumdjik machlak*), and another resembling satin. The fineness of these stuffs is much appreciated. The shawls and veils, know as *djar*, *tcharchef*, *zar*, and *réhidé*, produced in the province, are superior to similar products of other countries. Wines, liqueurs, and elixirs prepared in the same *vilayet*, such as *hara* and *rouhelhagat*, are much sought after. In certain villages of this province the women, who for a loom make use of four pieces of wood planted on the ground, weave carpets and *kilims* so admirably that they have been occasionally taken for Persian shawls. The silk and cotton tissues of Bagdad are worthy of attention. If the *machlaks* (a kind of cloth woven of camels' hair) were more carefully prepared, it is said they would find a ready sale in all parts of the world. At Saïda silks and woollens are produced, and indigo is largely grown. In the *vilayet* of Tripoli (Asiatic Turkey) olives and tobacco are produced, and the sponge fishery is carried on to some extent. Manufactured articles are silk, soap, tissues, and girdles. Oranges, lemons, and other fruits are also extensively grown, while a large export trade is carried on in wool. In Arabia, coffee, saffron, and vegetable ivory are found. The finest coffee is produced at Yemen. The exports from Tripoli (Barbary) comprise ivory, ostrich feathers, olive oil, wool, cereals, and cattle. All kinds of vegetables are grown there, and there is a species of madder, the colour of which is a deep red This colour is used in dyeing, and considerable quantities of it are exported. There are various descriptions of dates grown, and from them is extracted a species of brandy called *Boha*, which is exported in earthen jars known as *goul-goul*. In cutting the upper part of the date trees, a liquid exudes of a dark colour and very sweet taste, which is called *leken*, and which makes an excellent beverage when fresh. In about six hours this liquid ferments and is transformed into a wine with an agreeable taste. Olives are one of the principal sources of the wealth of the country. There is one description of olive oil which is called *harati*, and this is considered superior to the best oil of Crete. There are also found in great abundance fruits, such as apples, figs, grapes, mulberries, peaches, apricots, sweet oranges and citrons. Melons are grown on a large scale, and those called *kalvaz* have an exquisite flavour. The principal description of sheep is the *karaman*, which breeds twice a year. Goats and camels are also found in great numbers. In Turkey the industries adapt themselves to the tastes and and habits of the inhabitants, and, therefore, are not much appreciated abroad. To quote one example among many others, mention is made of the tissues known as *aladja* and *buluk*, and which are manufactured in the *sandjak* of Orfa. These are now woven exactly in the same way, and on the same pattern as they were 500 years ago. There are two species of camel reared in Bagdad, and flocks of sheep are abundant in various districts of this province. The skins are used in the manufacture of boots (*babouches*) and sandals (*yémeni*). The horses reared in this *vilayet* have not their equal in any part of the world. Attempts have been made from time to time to reproduce the race of Bagdad horses in France, England, and Russia, with the result only of improving the existing breeds in those countries. The soil there is exceedingly fertile, and the principal products are barley, wheat, rice, and dates. Independently of these products, cotton, sesamum, beans, peas, and lentils are largely grown, while every description of fruit abounds. These products are exported in large quantities to India and European countries. Opium is also largely cultivated. At Helé, part of the population is

engaged in agricultural and part in indnstrial pursuits. The *kefié*, *tcharcheb*, *abani*, *machlak*, and other woollen and cotton stuffs are woven there. Weaving, wood-carving, and shoe-making are extensively engaged in, while these industries are also carried on in Bagdad. The industry which principally affords the means of livelihood to the Jewish inhabitants is the weaving of the *abani*. In localities such as Nedjif, Echref, and Echra, *machlaks* of good quality are manufactured. Materials for scent-making are found in abundance in the *vilayet* of Crete, and they are also found at Smyrna, Broussa, and in many other provinces. Soap is the most important of the manufactured articles of the island of Crete, and important transactions have taken place in this article. The most important industry of Rethymo, in the same island, consists in the manufacture of soap and olive oil. In the island of Chio the plain of Cambos is covered with gardens planted with orange trees, olive trees, and mastic trees. The products of the woollen, silk, and cotton manufacture have considerable importance at Beyrout. There are also exports from this province of olives, gall-nuts, silk cocoons, and madder. Samsoun produces tobacco, while the port of Sinope is important on account of its timber. Harness-making and several other industries exist at Erzeroum; the products, however, are not exported, but are required for local requirements. The principal source of the wealth of the peasant is the rearing of domestic animals, such as oxen, goats, and sheep. Near the Persian frontier, near the *vilayets* of Van and the *sandjak* of Hékiari, cattle are found in large numbers, and from these districts considerable quantities of skins are exported. The wool produced in these districts is used in the tissues manufactured to suit the requirements of local consumers.

FLORENTINE PIETRA DURA OR MOSAIC WORK.

Her Majesty's Consul-General at Florence says that the proper technical term for the so-called Florentine mosaics is works in *commesso*. They are composed of delicate slices of stones, carefully cut into shape, arranged and joined together (*commessi*) with a fine cement, and then fitted into a thin slab of marble. The pictures are produced by the natural tints of the stones, the selection of which require great taste and skill. Works in *commesso* are executed in the following manner:—After the design has been prepared, the thin slices of stone selected for the various parts are distributed among a certain number of workmen, each of whom completes the portion of the design entrusted to him, the whole subject being subsequently united. The stones, after being cut into the required shapes, are carefully set together with a cement made of wax and mastic (*pece greca*), heat being used to bind them together. Slate is employed to support the work during its progress, and to line it when complete. At each stage the first lining affixed to the separate parts is ground down and a fresh one affixed, so that an even surface may always be secured. When the complete design is fitted into the marble slab prepared for its reception, the whole of the base is again ground down to a perfect plane, and is lined with a fresh backing of slate. The fitting is performed with the greatest care, the edges of the several parts being filed until the exact dimensions have been attained. The whole surface is afterwards polished, so that the lines of juncture are rendered almost invisible. To bind on the lining heat is used, as also for uniting the smaller pieces. The operation is very carefully performed, so that no more cement than is absolutely required should remain between the parts that have been joined together. The first operation of sawing the stones into thin slices, from 2½ to 3 millimetres in thickness, is performed by means of thin blades of iron or copper, emery powder giving the required friction. The slices are further sawn into the shapes required to form the various parts of the design by iron or copper wire attached to bows, and always with the aid of emery. The finest emery powder *(poltiglia)* is used for polishing the surface of the stones, and emery is employed for grinding down the linings. For this purpose the work is placed on a fixed slab of marble or slate, iron plates of various sizes and thicknesses, according to the dimensions of the slab, and having wooden handles, being steadily worked over it by one or two men, as required. Sir Dominic Colnaghi says that it would be interesting to trace the origin of this art, and to follow its development from classic times, through Siena to the present style of work, which began to be practised about the middle of the 16th century. Portraits, landscapes, and architectural views were first produced, but it was soon felt that these subjects were unsuited to the materials employed. Decorative designs and imitations of fruits and flowers therefore took their place, and form the most successful subjects of modern works executed in *pietre dure*. It has been doubted whether the introduction of the art of working in mosaic into Florence, under the patronage of the Grand Dukes of the house of Medici, is due to Tuscan or Lombard artists, as it would appear to have flourished contemporaneously in both regions. While, however, it has died out—or nearly so—in Lombardy, it has survived in Tuscany, to become an important branch of Florentine industry. To provide stones for the works in real *pietre dure*, Europe, Asia, and the North of Africa have been laid under contribution, and the Royal Factory possesses a large collection of stones valued at some 20,000 lire. Among the principal stones employed are amethysts, agates, the sardonyx and chalcedony, flints, and many varieties of jasper, pebbles from the Arno (which generally contain a large proportion of lime), and petrified woods. Among the rocks which are chiefly used for works of decoration are red

Oriental, Egyptian, and other granites, *verde di Corsica*, labradorite, antique porphyry, green porphyry, Oriental serpentine, jade, basalt, silicious Breccia, and *lapis lazuli*. Black marble from Belgium is largely used as a foundation, and slate, as has already been mentioned, is employed as a lining for works in *commesso*. The hardness of the materials employed, requiring patient industry to work them, accounts for the costliness of works in *pietre dure*, of which 75 to 80 per cent. is attributed to labour. The commercial articles met with in the Florentine shops are chiefly composed of the softer qualities of calcareous stones, while shells are used for the white and pink tints, and coral is occasionally inserted. The workmanship, design, and effect are often excellent, but they are able to be produced at much less cost than the works executed at the Royal Factory, of which the following is a short notice. Although artists in mosaic had been employed by Duke Cosmo de Medici in previous years, the foundation of the Royal Factory of *pietre dure* in Florence may, perhaps, be considered to date from about the year 1754, when some rooms in the Casino di San Marco were assigned for the residence of the masters of the art. The factory was principally founded to carry out the works of the great sepulchral chapel of the Medici in S. Lorenzo. This chapel would appear always to have been intended to receive the monuments of the princes of the House of Medici, and never, as tradition avers, to become the receptacle of the tomb of our Lord, which was to have been conveyed to Florence from the Holy Land by the Druse Emir Faccardin (Fakhr-ed-Din). The slow progress of the chapel enabled the artists employed in the factory to execute other works, which were presented by the later Medici princes, on different occasions, to foreign sovereigns, thus extending the reputation of the factory. Some of the artists appear to have tried their fortunes in foreign lands, and it is thought that a part at least of the works in *pietre dure*, executed in the Taj Mahal of Agra, are of Florentine origin. In 1723 a small factory was founded at Naples, which existed until 1860, when it was suppressed; but no rival rose to compete with Florence until the establishment of the Imperial works at St. Petersburg for mosaic in relief, about the year 1840. The mosaics executed in the factory of the Vatican, at Rome, are of an entirely different character from the Florentine works in *commesso*. On the overthrow of the Grand Ducal Government in 1860, the works of the Medicean chapel were suspended until the beginning of 1883. Since this date about 135 square metres of the pavement executed in *commesso* on a large scale have been completed. The total area of flooring of the octagon, excluding the recesses, is 642 square metres. The completion of the chapel has been entrusted by Ministerial decree to the Royal Factory. The total cost up to the present time is estimated at 16,300,000 lire, or £625,000. The average annual value of the production of the factory is calculated at 52,000 lire, of which about 12,000 represent works sold in Italy and abroad on private commissions, and the remainder in part works placed in the museum of the factory, and partly repairs in mosaics, &c., existing in the Royal Galleries of Florence, from which the administration of the factory now depends. The works executed are marble table tops, panels for furniture, caskets, letter weights, decorated in *commesso*, both flat and in relief, vases, cups, statuettes, columns, and other ornamental works. At the present time, says Consul-General Colnaghi, a large piece is being executed, combining all the different kinds of works—*commesso*, *intarsio*, relief, and in the round. The work consists of a large black vase, richly decorated with flowers, fruit, birds, &c., and is the first example of *commesso* work applied to a curved surface. All the work is carried on by hand; there is no machinery, though this is much needed, it is said, in the sawing department. For about two centuries and a half the production of the Florentine mosaics had remained a monopoly of the Royal Factory, it was not till 1825 that there was an industrial application of the art to small articles of jewellery and ornaments. To effect this, however, the true *pietra dura* had of necessity to be put on one side, and its place taken by calcareous stones and shells, thus allowing the work to be executed at reasonable rates. Between 1863 and 1873, the period when the city was the capital of Italy, there was especially a considerable increase in the industry. Since 1873 a variety of causes—such as the removal of the capital, the cholera (which caused a temporary diminution in the number of visitors to Florence), and changes of fashion—have led to a decrease in the production. The outfit of a mosaicist is very simple. With a small table, a basin of water, a brazier, a vice, some copper and iron blades to be used as files, a bow strung with iron wire, a little emery powder, and a few stones already cut into slices, which cost only a few francs, his equipment is complete.

THE TRADE IN QUININE IN THE UNITED STATES.

The *New Yorker Handels Zeitung*, in a recent issue, gives some particulars respecting the condition of the quinine market. It states that quinine has suffered of late years a remarkable fall in price —a fall which deserves some attention. The value per ounce has fallen from about 12s. to 2s., but it is particularly the causes that led to this heavy fall that have remained up to the present unexplained. Quinine, as is well known, is a tonic and a stimulant of the highest order, and it has this advantage over many other stimulants, that if it is taken in moderation its use does not become an absolute necessity. Since the year 1820 this product has been extracted from Peruvian bark. In that year Peru was the sole country of production of the yellow bark of which

the finest description only was used for the production of quinine, and the Government of that country made a monopoly of the product. The rise in the price of the bark was such at one period that quinine was sold at about 16s. an ounce. Later, thanks to the improvements that had been made in chemistry, a method was discovered of extracting quinine not only from bark of the best qualities, but also from inferior barks coming from countries other than Peru; the prices then fell to about 4s. the ounce. The increased demand upon the market resulted, however, in a fresh rise in price, which lasted as long as the industry had only the natural products of South America as a source for the production of the raw material that is to say, until 1861, or thereabouts. About that time both England and the Netherlands commenced the cultivation of the cinchona tree in their Indian possessions. The commercial importance of the cinchona plantations did not, however, make itself felt until the year 1876, when 16,000 lbs. of bark coming from Ceylon were placed upon the market. In 1885 the shipments from Ceylon alone amounted to 15,000,000 lbs. weight. At the same time as that quantity of the raw material was increasing in so remarkable a manner, the proportion of pure quinine produced from the bark coming from the new plantations amounted to 8 per cent., while the yield of the South American did not exceed 1·5 per cent. It may be added that by the old methods of procedure it was necessary to work the bark for three days to extract the quinine, while now twenty-four hours are sufficient for the purpose. The annual consumption of quinine throughout the world is estimated at from 6,000,000 to 7,000,000 ounces, and the United States figures in this amount to the extent of about two-fifths. Three-fourths of the quinine used in the United States were formerly manufactured in the country itself; at the present time the production of the United States is barely sufficient to supply a quarter of the amount required. The Customs duty of 20 per cent. upon quinine was abolished in 1879, and the American producers affirm that without a protective duty they cannot compete with foreign producers, particularly with the Germans, who export to the United States their excess production and sell it at any sacrifice. Seven or eight factories for the preparation of quinine were established in the United States; there now remains but three, one of which only is at work all through the year, the second only works at rare intervals, and the third is unoccupied. In 1888 the European manufacturers endeavoured, but unsuccessfully, to keep up prices, and they fell lower than ever. According to one of the principal German manufacturers this attempt is not likely to be renewed. During the nine months ended June, 1888, the shipments of cinchona bark from Ceylon amounted to 8,715,237 pounds, a falling off of 2,429,009 pounds, as compared with the corresponding period of 1887. This diminution of the exports caused a rumour to spread that the speculators were about to buy and keep the prices firm in view of a rise, but the fact was lost sight of that the Java production was rapidly increasing, and becoming of very great importance. It is said that more than sixty new private plantations have been laid out in that island, and in the autumn of 1889 shipments of bark from these plantations will commence to be made, and these are exclusive of the Government plantations, and the old private plantations which, already supplying bark, yielded more than 1,000,000 pounds in 1885, and are expected this year to supply more than 4,000,000 pounds for shipment. Other plantations are also spoken of, laid out with a description of cinchona tree, the bark of which is expected to yield an average of 10 per cent. of pure quinine. On all sides it is admitted that the stocks in the warehouses are very considerable. In September last it was estimated that there were 3,000,000 ounces of quinine at the orders of buyers, and that there was no probability of a rise in prices. This opinion appears to have been well founded. The following tabular statements show the fluctuations in the imports, and the prices in the United States since the year 1886:—

Years.	Imports of Quinine. Ounces.	Average value per ounce at the Customs. s.	d.
1886	1,251,556	2	11
1887	2,180,157	2	1
1888	1,603,936	1	8

The imports into the United States during the first three months of 1889 amounted to 732,014 ounces of an average value of 1s. 3d. an ounce, and during the period comprised between January 1st and June 30th, they amounted to 1,650,000 ounces—nearly twice as much as was imported during the corresponding period of 1888—the price barely exceeding one-half of those realised during the corresponding period. The following statement shows the imports of cinchona bark during the last three years, together with the average value per pound:—

Years.	Imports. lbs.	Average Value per lb. s.	d.
1886	4,447,082	0	10
1887	4,787,311	0	7½
1888	2,801,457	0	6

The imports for the first three months of 1889 amounted to 504,944 pounds of an average value of a little over 5d. per pound. In conclusion, the *New Yorker Handels-Zeitung* says that the old high prices of quinine would appear to be attributed to a restricted supply of the raw material giving a small yield of quinine; to an increase in the demand which it was not possible to satisfy, and to the primitive methods of production. The causes of the low prices would appear to be—supplies of the raw material increasing indefinitely; a comparatively steady and limited demand; improved methods of production, and a keen competition among European manufacturers.

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Proceedings of the Society.

CANTOR LECTURES.

THE DECORATION AND ILLUSTRATION OF BOOKS.

By Walter Crane.

Lecture III.—Delivered March 18th, 1889.

As I indicated at the outset of my first lecture, my purpose is not to give a complete historical account of the decoration and illustration of books, but rather to dwell on the artistic treatment of the page from my own point of view as a designer. So far, however, the illustrations I have given, while serving their purpose, also furnished a fair idea of the development of style and variation of treatment of both the MS. and printed book under different influences, from the 6th to the close of the 16th century, but now I shall have to put on a pair of seven-league boots, and make some tremendous skips.

We have seen how, at the period of the early Renaissance, two streams met, as it were, and mingled, with very beautiful results. The freedom, the romance, the naturalism of the later Gothic, with the newly awakened Classical feeling, with its grace of line and mythological lore. The rich and delicate arabesques in which Italian designers delighted, and which so frequently decorated, as we have seen, the borders of the early printer, owe also something to Oriental influence, as indeed their name indicates. The decorative beauty of these early Renaissance books (such as were shown in the lantern last time) were really, therefore, the outcome of a very remarkable fusion of ideas and styles. Printing, as an art, and book decoration attained a perfection it has not since reached. The genius of the greatest designers of the time was associated with the new invention, and expressed itself with unparalleled vigour in the woodcut; while the type-founder, being still under the influence of a fine traditional style in handwriting, was in perfect harmony with the book decorator or illustrator. Even geometric diagrams were given without destroying the unity of the page, and we have seen what faithful and characteristic work was done in illustrations of plants and animals, without loss of designing power and ornamental sense.

This happy equilibrium of artistic quality and practical adaptation after the middle of the 16th century began to decline. The classical influence, which had been only felt as one among other influences, became more and more paramount over the designer, triumphing over the naturalistic feeling, and over the Gothic and Eastern ornamental feeling; so that it might be said that, whereas Mediæval designers sought after colour and decorative beauty, Renaissance designers were influenced by considerations of line, form, and relief. This may have been due in a great measure to the fact that the influence of the antique and Classical art was a sculpturesque influence, mainly gathered from statues and relievos, gems and medals, and architectural carved ornaments, and more through Roman than Greek sources. While suggestions from such sources were but sparingly introduced at first, they gradually seemed to outweigh all other motives with the later designers, whose works often suggest that it is impossible to have too much Roman costume or too many Roman remains, which crowd their Bible subjects, and fill their borders with overfed pediments, corpulent scrolls, and volutes, and their interstices with scattered fragments and attitudinising personifications of Classical mythology. The lavish use of such materials were enough to overweight even vigorous designers like Virgil Solis, who though able, facile, and versatile as he was, seems but a poor substitute for Holbein.

What was at first an inspiriting, imaginative, and refining influence in art became finally a destructive force. The youthful spirit of the early Renaissance became clouded and oppressed, and finally crushed with a weight of pompous pedantry and affectation. The natural development of a living style in art

became arrested, and authority, and an endeavour to imitate the antique, took its place.

The introduction of the copper-plate marked a new epoch in book illustration, and wood-engraving declined with its increased adoption, which, in the form it took, as applied to books, in the 17th and 18th centuries, was certainly to the detriment and final extinction of the decorative side.

It has already been pointed out how a copper-plate, requiring a different process of printing, and exhibiting as a necessary consequence such different qualities of line and effect, cannot harmonise with type and the conditions of the surface-printed page, since it is not in any mechanical relation with them. This mechanical relation is really the key to all good and therefore organic design; and therefore it is that design was in sounder condition when mechanical conditions and relations were simpler. A new invention often has a dislocating effect upon design. A new element is introduced, valued for some particular facility or effect, and it is often adapted without considering how—like a new element in a chemical combination—it alters the relations all round.

Copper-plate engraving was presumably adopted as a method for book-illustration for its greater fineness and precision of line, and its greater command of complexity in detail and chiaroscuro, for its purely pictorial qualities in short, and its adoption corresponded to the period of the ascendancy of the painter above other kinds of artists.

As regards the books of the 17th century, while "of making many books there was no end," and however interesting for other than artistic reasons, but few would concern our immediate purpose. Wood-cuts, headings, initials, tail-pieces, and printers' ornaments continued to be used, but greatly inferior in design and beauty of effect to those of the 16th century. The copper-plates introduced are quite apart from the page ornaments, and can hardly be considered decorative, although in the pompous title pages of books of this period they are frequently formal and architectural enough, and, as a rule, founded more or less upon the ancient arches of triumph of Imperial Rome.

Histories and philosophical works, especially towards the end of the 17th and beginning of the 18th centuries, were embellished with pompous portraits in frames of more or less classical joinery, with shields of arms, the worse for the decorative decline of heraldry, underneath. Travels and topographical works increased, until by the middle of the 18th century we have them on the scale of Piranesi's scenic views of the architecture of ancient Rome.

The love of picturesqueness and natural scenery, or, perhaps, landscape gardening, gradually developing, concentrated interest on qualities the antithesis of constructive and inventive design, and drew the attention more and more away from them, until the painter, pure and simple, took all the artistic honours, and the days of the foundation of academies only confirmed and fixed the idea of art in this restricted sense in the public mind.

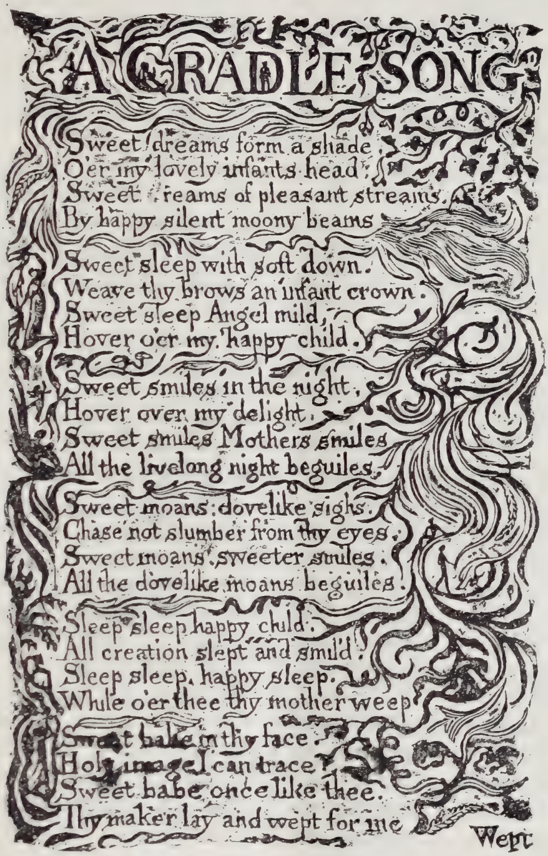
Hogarth, who availed himself of the copper-plate and publication in book form of his pictures, was yet wholly pictorial in his sympathies, and his instincts were dramatic and satiric rather than decorative. Able painter as he was in his own way, the interest of his work is entirely on that side, and is rather valuable as illustrating the life and manners of his time than as furnishing an example of book illustration, and his work certainly has no decorative aim.

Chodowiecki, who did a vast quantity of steel frontispieces and illustrations for books on a small scale, with plenty of character, must also be regarded rather as a maker of pictures for books. He is sometimes mentioned as kindred in style to Stothard, but Stothard was much more of an idealist, and had, too, a very graceful decorative sense from the classical point of view. His book designs are very numerous, chiefly engraved on steel, and always showing a very graceful sense of line and composition. His designs to Rogers's "Poems," and "Italy," are well-known, and, in their earlier woodcut form, his groups of Amorini are very charming.

Flaxman had a high sense of sculpturesque style and simplicity, and great feeling and grace as a designer, but he can hardly be reckoned as a book decorator. His well-known series to Homer, Hesiod, Æschylus, and Dante are strictly distinct series of illustrative designs, to be taken by themselves without reference to their incorporation in, or relation to, a printed book. Their own lettering and explanatory text is engraved on the same plate beneath them, and so far they are consistent, but are not in any sense examples of page treatment or spacing.

We now come to a designer of a very different type, a type, too, of a new epoch,

whatever resemblance in style and method there may be in his work to that of his contemporaries. William Blake is distinct, and stands alone. A poet and a seer, as well as a designer, in him seemed to awake something of the spirit of the old illuminator. He was not content to illustrate a book by isolated copper or steel plates apart from the text, although in his craft as engraver he constantly carried out the work of others. When he came to embody his own thoughts and dreams, he recurred quite spontaneously to the methods of the maker of the MS. books. He became his own caligrapher, illuminator, and miniaturist, while availing himself of the copper-plate (which he turned into a surface printing block) and the printing press for the reproduction of his designs, and in some cases for producing them in tints. His hand-coloured drawings, the borderings and devices to his own poems, will always be things by themselves.



A CRADLE SONG

Sweet dreams form a shade
O'er my lovely infants head.
Sweet dreams of pleasant streams,
By happy silent moony beams

Sweet sleep with soft down.
Weave thy brows an infant crown.
Sweet sleep Angel mild,
Hover o'er my happy child.

Sweet smiles in the night,
Hover over my delight.
Sweet smiles Mothers smiles
All the livelong night beguiles.

Sweet moans, dovelike sighs,
Chase not slumber from thy eyes.
Sweet moans, sweeter smiles,
All the dovelike moans beguiles.

Sleep sleep happy child.
All creation slept and smil'd.
Sleep sleep, happy sleep.
While o'er thee thy mother weep

Sweet babe in thy face.
Holy image I can trace.
Sweet babe once like thee.
Thy maker lay and wept for me

Wept

FIG. 11.—PAGE FROM "SONGS OF INNOCENCE," 1789. WILLIAM BLAKE.

His treatment of the resources of black and white, and sense of page decoration, may be best judged perhaps by a reference to his "Book of Job," which contains a fine series suggestive and imaginative designs. We seem to read in Blake something of the spirit of the Mediæval designers, through the sometimes mannered and semi-classic forms and treatment, according to the taste of his time; while he embodies its more daring aspiring thoughts, and the desire for simpler and more humane conditions of life. A revolutionary fire and fervour constantly breaks out both in his verse and in his designs, which show very various moods and impulses, and comprehend a wide range of power and sympathy. Sometimes mystic and prophetic, sometimes tragic, sometimes simple and pastoral.

Blake, in these mixed elements, and the extraordinary suggestiveness of his work and the freedom of his thought, seems nearer to us

than others of his contemporaries. In his sense of the decorative treatment of the page, too, his work bears upon our purpose. In writing with his own hand and in his own character the text of his poems, he gained the great advantage which has been spoken of—of harmony between text and illustration. They become a harmonious whole, in complete relation. His woodcuts in Thomson's "Virgil," though perhaps rough in themselves, show what a sense of colour he could convey, and of the effective use of white line.

Among the later friends and disciples of Blake, a kindred spirit must have been Edward Calvert, examples from some of whose book illustrations are here given. They are full of poetic feeling and imagination, and sense of colour. I am indebted for the loan of them to Mr. William Blake Richmond, whose father, Mr. George Richmond, was a friend of William Blake and Calvert, as well as of John Linnell and of Samuel Palmer, who carried on the traditions of this English poetic school to our own times; especially the latter, whose imaginative drawings—glowing sunsets over remote hill-tops, romantic landscapes, and pastoral sentiment—were marked features in the room of the Old Water Colour Society, up to his death in 1881. His etched illustrations to his edition of "The Eclogues of Virgil," are a fine series of beautifully designed and poetically conceived landscapes; but they are strictly a series of pictures printed separately from the text. Palmer himself, in the account of the work given by his son, when he was planning the work, wished that William Blake had been alive to have designed his woodcut headings to the "Eclogues."

To Thomas Bewick and his school is due the revival of wood-engraving as an art, and its adaptation to book illustration. Bewick had none of the imaginative poetry of the designers just named, although plenty of humour and satire, which he compressed into his little tail pieces. He shows his skill as a craftsman in the treatment of the wood block, in such works as his "British Birds;" but here, although the wood-engraving and type are in perfect mechanical relation, there is no sense of decorative beauty or ornamental spacing whatever, and, as drawing, it has none of the designer's power such as we found in the illustrations of Gesner and Matthiolus at Basle, in the middle of the 16th century. There is a very literal and plain presentment of facts as regards the bird and its plumage, but with scarcely more than the taste of the average stuffer and mounter in the composition of the picture, and no regard whatever to the design of the page as a whole.

It was, however, a great point to have asserted the claims of wood-engraving, and demonstrated its capabilities as a method of book illustration.

Bewick founded a school of very excellent craftsmen, who carried the art to a wonderful degree of finish. In both his and their hands it became quite distinct from literal translation of the drawing, which, unless in line, was treated by the engraver with a line, touch, and quality all his own, the use of white line, and the rendering of tone and tint necessitating a certain power of design on his part, and gave him as important a position as the engraver on steel held in regard to the translation of a painted picture.

Such a book as Northcote's "Fables," published 1828-29, each fable having a head-piece drawn on wood from Northcote's design by William Harvey—a well-known and copious illustrator of books up to comparatively recent times—and with initial letters and tail-pieces of his own, shows the outcome of the Bewick school. Finally "fineness of line, tone, and finish—a misused word," as Mr. W. J. Linton says, "was preferred to the simple charm of truth." The wood engravers appeared to be anxious to vie with the steel engravers in the adornment of books, and so far as adaptation was concerned, they had certainly all the advantage on their side. The ornamental sense, however, had everywhere declined; pictorial qualities, fineness of line, and delicacy of tone was sought after almost exclusively.

Such books as Rogers's "Poems" and "Italy," with vignettes on steel from Thomas Stothard and J. M. W. Turner, is characteristic of the taste of the period, and shows about the high-water mark of the skill of the book engravers on steel. Stothard's designs are the only ones which have claims to be decorative, and he is always a graceful designer. Turner's landscapes, exquisite in themselves, and engraved with marvellous delicacy, do not in any sense decorate the page, and from that point of view are merely shapeless blots of printers' ink of different tones upon it, while the letterpress bears no relation whatever to the picture in method of printing or design, and has no independent beauty of its own. Book illustrations of this type—and it was a type which largely prevailed during the second quarter of the century—are simply pictures without frames.

I have not mentioned Gustave Doré, who fills so large a space as an illustrator of books, because though possessed of a weird imagination, and a poetic feeling for dramatic landscapes and grotesque characters, as well as extraordinary pictorial invention, the mass of his work is purely scenic, and he never shows the decorative sense, or considers the design in relation to the page. His best and most spirited and sincere work is represented by his designs in the "Contes Drolatiques."

No survey of book illustration would be complete which contained no mention of William James Linton—whom I have already quoted. I may be allowed to speak of him with a peculiar regard and respect, as I may claim him as a very kind early friend and master. As a boy I was, in fact, apprenticed to him for the space of three years, not indeed with the object of wielding the graver, but rather with that of learning the craft of a draughtsman on wood. This, of course, was before the days of the use of photography, which has since practically revolutionised the system not only of drawing for books but of engraving also. It was then necessary to draw on the block itself, and to thoroughly understand what kind of work could be treated by the engraver.

I shall always regard those early years in Mr. Linton's office as of great value to me, as, despite changes of method and new inventions, it gave me a thorough knowledge of the mechanical conditions of wood-engraving at any rate, and has implanted a sense of necessary relationship between design, material, and method of production—of art and craft, in fact—which cannot be lost, and has had its effect in many ways.

Mr. Linton, too, is himself a notable historic link, carrying on the lamp of the older traditions of wood-engraving to these degenerate days, when whatever wonders of literal translation, and imitation of chalk, charcoal, or palette and brushes, it has exhibited under spell of American enterprise—and I am far from denying its achievements as such—it cannot be said to have preserved the distinction and independence of the engraver as an artist or original designer in any sense. When not extinguished altogether by some form of automatic reproductive process, he is reduced to the office of "process-server"—he becomes the slave of the pictorial artist. The picturesque sketcher with his "bits" and "effects," which, moreover, however sensational and sparkling they may be in themselves, have no reference as a rule to the decoration of the page, being in this sense no more than more or less adroit splashes of ink upon it, which the text, torn into an irregularly ragged edge, seems instinctively to shrink from touching, squeezing itself together like the passengers in a crowded omnibus might do reluctant to admit a chimney-sweep.

While, by his early training and practice, he is united with the Bewick school, Mr. Linton—himself a poet, a political writer, a scholar, as well as designer and engraver—having been associated with the best-known engravers and designers for books during the middle of the century, and having had art of such a different temper and tendency as that of Rosetti pass through his hands, and seen the effect of many new impulses, is finally face to face with what he himself has called the "American New Departure." He is therefore peculiarly and eminently qualified for the work to which he has addressed himself—his great work on "The Masters of Wood Engraving," which he is now preparing for the press, which promises to be in every way complete and sumptuous.

The new movement in painting in England, known as the pre-Raphaelite movement, which dates from about the middle years of our century, was in every way so remarkable and far-reaching, that it is not surprising that it should leave its mark upon the illustrations of books. That form of luxury known as the modern gift-book, which, in the course of the twenty years following 1850, often took the shape of selections from or editions of the poets plentifully sprinkled with little pictorial vignettes engraved on wood. Birket Foster, John Gilbert, and John Tenniel were leading contributors to these collections.

About 1859 appeared an edition of "Tennyson's Poems" from the house of Moxon. This work, while having the general characteristics of the prevailing taste—an accidental collection of designs, the work of designers of varying degrees of substance, temper, and feeling, casually arranged, and without the slightest feeling for page decoration or harmony of text and illustration—yet possessed one remarkable feature which gives it a distinction among other collections, in that it contains certain designs of the chief leaders of the pre-Raphaelite movement, D. G. Rossetti, Millais, and Holman Hunt.

I give three of the Rossetti designs in the lantern. The "S. Cecilia" and the "Morte d'Arthur" were engraved by the Brothers

Dalziel. The "Sir Galahad" by Mr. W. J. Linton. It seems to me that the last gives the spirit and feeling of Rossetti, as well as his peculiar touch, far more successfully. These designs, in their poetic imagination, their richness of detail, sense of colour, passionate, mystic, and romantic feeling, and earnestness of expression mark a new epoch. They are decorative in themselves, and, though quite distinct in feeling, and original, they are more akin to the work of the Mediæval miniaturist than anything that had been seen since his days. Even here, however, there is no attempt to consider the page or to make the type harmonise with the picture, or to connect it by any bordering or device with the book as a whole, and being sandwiched with drawings of a very different tendency, their effect is much spoiled. In one or two other instances where Rosetti lent his hand to book illustration, however, he is fully mindful of the decorative effect of the page. I remember a title page to a book of poems by Miss Christina Rossetti, "Goblin Market," which showed this. His sonnet on the sonnet too, in which the design encloses the text of the poem, written

Fig. 12.—D. G. Rossetti's Sir Galahad, from Moxon's illustrated Tennyson's Poems, 1857.

out by himself, is another instance; being hurried, however, I have not been able to obtain them for this lecture.

Some of the designs made for a later work (Dalziel's Bible Gallery, about 1865-70) also show the effect of the pre-Raphaelite influence, as well as, in the case of the designs of Sir Frederick Leighton and Mr. Poynter, the influence of Continental ideas and training. I saw some of these drawings on the wood at the time I remember. For study and research, and richness of resource in archæological detail, as well as firmness of drawing, I thought Mr. Poynter's designs were perhaps the most remarkable. A strikingly realised picture, and a bright and successful wood-engraving, is Mr. Madox Brown's design of "Elijah and the Widow's Son." There is a dramatic intensity of expression about his other one also, "The Death of Eglon." Still, at best, we find that these are but carefully studied pictures rendered on the wood. The pre-Raphaelite designs show the most decorative sense, but they are now issued quite distinct from the page, whatever

was the original intention, and while they may, as to scale and treatment, be justly considered as book illustrations, and as examples of our more important efforts in that direction at that time, they are not page decorations.

As, until recently, I suppose I was scarcely known out of the nursery, it is meet that I should offer some remarks upon children's books. Here, undoubtedly, there has been a remarkable development and great activity of late years. We all remember the little cuts that adorned the books of our childhood. The ineffaceable quality of these early pictorial and literary impressions afford the strongest plea for good art in the nursery and the schoolroom. Every child takes in more through his eyes than his ears, and I think much more advantage might be taken of this fact.

If I may be personal, let me say that my first efforts in children's books were made in association with Mr. Edmund Evans. Here, again, I was fortunate to be in association with the craft of colour-printing, and I got to understand its possibilities. The books for babies, current at that time—about 1865 to 1870—of the cheaper sort called toy books were not very inspiriting. These were generally careless and unimaginative woodcuts, very casually coloured by hand, dabs of pink and emerald green being laid on across faces and frocks with a somewhat reckless aim. There was practically no choice between such as these and cheap German highly-coloured lithographs. The only attempt at decoration I remember was a set of coloured designs to nursery rhymes by H. S. Marks, which had been originally intended for cabinet panels. Bold outlines and flat tints were used.

It was, however, the influence of some Japanese printed pictures given to me by a lieutenant in the navy, who had brought them home from there as curiosities, which I believe, though I drew inspiration from many sources, gave the real impulse to that treatment in strong outlines, and flat tints and solid blacks, which I adopted with variations in books of this kind from that time (about 1870) onwards. Since then I have had many rivals for the favour of the nursery constituency, notably my late friend Randolph Caldecott, and Miss Kate Greenaway, though in both cases their aim lies more in the direction of character study, and their work is more of a pictorial character than strictly decorative.

Children's books and so-called children's books hold a peculiar position. They are attractive to designers of an imaginative tendency, for in a sober and matter-of-fact age they afford perhaps the only outlet for unrestricted flights of fancy open to the modern illustrator, who likes to revolt against "the despotism of facts." While on children's books, the poetic feeling in the designs of E. V. B. may be mentioned, and I mind me of some charming illustrations to a book of Mr. George Macdonald's, "At the Back of the North Wind," designed by Mr. Arthur Hughes.

There is no doubt that the opening of Japanese ports to Western commerce, whatever its after effects—including its effect upon the arts of Japan itself—has had an enormous influence on European and American art. Japan is a country very much, as regards its arts and handicrafts with the exception of architecture, in the condition of a European country in the Middle Ages, with wonderfully skilled artists and craftsmen in all manner of work of the applied and decorative kind, who are under the influence of a free and informal naturalism. Here at least was a living art, an art of the people, in which traditions and craftsmanship were unbroken, and the results full of attractive variety, quickness, and naturalistic force. What wonder that it took Western artists by storm, and that its effects have become so patent, though not always happy, ever since. We see unmistakable traces of Japanese influences, however, almost everywhere—from the Parisian impressionist painter to the Japanese fan in the corner of trade circulars, which shows it has been adopted as a stock printers' ornament. We see it in the sketchy blots and lines, and vignetted naturalistic flowers which are sometimes offered as page decorations, notably in American magazines and fashionable etchings. We have caught the vices of Japanese art certainly, even if we have assimilated some of the virtues.

In the absence of any architecture or substantial constructive sense, the Japanese artists are not safe guides as designers. They may be able to throw a spray of leaves or a bird across a blank panel or sheet of paper, which is drawn with such consummate skill and certainty that it may delude us into the belief that it is a decorative design; but if an artist of less skill essays to do the like the mistake becomes obvious. Granted they have a decorative sense—the *finesse* which goes to the placing of a flower in a pot, of hanging a garland on a wall, or of placing a mat or a fan—taste, in short, that is a

different thing from real constructive power of design, and satisfactory filling of spaces.

When we come to their books, therefore, marvellous as they are, and full of beauty and suggestion—apart from their naturalism, *grotesquerie*, and humour—they do not furnish fine examples of page decoration as a rule.

These drawings of Hokusai's, the most vigorous and prolific of the more modern and popular school, are striking enough and fine enough, in their own way, and the decorative sense is never absent; controlled, too, by the dark border-line, they do fill the page, which is not the case always with the flowers and birds. However, I believe these accidental holes, blanks, and spaces to let are only tolerable because the drawing where it does occur is so skilful; and from tolerating we grow to like them, I suppose, and take them for signs of mastery and decorative skill. In their smaller applied ornamental designs, however, the Japanese often show themselves fully aware of a systematic plan or geometric base.

As regards the history and use of printing, the Japanese had it from the Chinese, who invented the art of printing from wooden blocks in the 6th century. "We have no record," says Professor Douglas,* "as to the date when metal type was first used in China, but we find Korean books printed as early as 1317 with movable clay or wooden type, and just a century later we have a record of a fount of metal type being cast to print an "Epitome of the Eighteen Historical Records of China." Printing is supposed to have been adopted in Japan "after the first invasion of the Korea by the armies of Hideyoshi, in the end of the 16th century, when large quantities of movable type books were brought back by one of his generals, which formed the model upon which the Japanese worked."†

I have mentioned the American development of wood-engraving. Its application to magazine illustration seems certainly to have developed or to have occurred with the appearance of very clever draughtsmen from the picturesque and literal point of view.

The admirable and delicate architectural and landscape drawings of Mr. Joseph Pennell, for instance, are well known, and, as purely illustrative work, fresh, crisp in drawing, and original in treatment, giving essential points of topography and local characteristics (with a happy if often quaint and unexpected selection of point of view, and pictorial limits), it would be difficult to find their match, but very small consideration or consciousness is shown for the page. If he will pardon my saying so, in some instances the illustrations are often daringly driven through the text, scattering it right and left, like the effect of a coach and four upon a flock of sheep.

Our American cousins have taught us another mode of treatment in magazine pages. It is what I have elsewhere described as the "card-basket style." A number of naturalistic sketches are thrown accidently together, the upper ones hiding the under ones partly, and to give variety the corner is occasionally turned down. There has been a great run on this idea of late.

However opinions may vary, I think there cannot be a doubt that in Elihu Vedder we have an instance of an American artist of great imaginative powers, and undoubtedly a designer of originality and force.

I had hoped to have procured some slides from his large work—the illustrations to the "Rubaiyat of Omar Khayyam," but here, again, I have been disappointed. Although the designs have no Persian character or feeling about them which one would have thought the poem and its feeling and imagery would naturally have suggested, yet they are a fine series, and show much decorative sense and dramatic power, and are quite modern in feeling.

Mr. Edwin Abbey is another able artist, who has shown considerable care for his illustrated page, in some cases supplying his own lettering; though he has been growing more pictorial of late. Mr. Alfred Parsons also, though he too often seems more drawn to the picture than the decoration. Mr. Heywood Sumner shows a charming decorative sense and imaginative feeling, as well as humour, and on the purely ornamental side; the accomplished decorations of Mr. Lewis Day exhibit his ornamental range and resource, which, though in general devoted to other objects, are conspicuous enough in certain book and magazine covers he has designed.

But I have left myself no time or space to attempt to do justice to the ability of my contemporaries, especially in the purely illustrative division.

The able artists of *Punch*, however, from John Leech to Linley Sambourne, have done much to keep alive a vigorous style of drawing in line, which, in the case of Mr. Sambourne,

* Guide to the Chinese and Japanese Illustrated Books in the British Museum.

† Satow. "History of Printing in Japan."

is united with great great invention and designing power.

I can only just briefly allude to certain powerful and original modern designers of Germany, where, indeed, the old vigorous traditions of woodcut and illustrative drawing seem to have been kept more unbroken than elsewhere.

On the purely character-drawing, pictorial and illustrative side, there is of course Menzel, thoroughly modern, realistic, and dramatic. I am thinking more perhaps of such men as Alfred Rethel, whose designs of "Death the Friend" and "Death the Enemy," two large woodcuts, are well known. I remember also a very striking series of designs of his, a kind of modern "Dance of Death," which appeared about 1848, I think. Schwind is another whose designs to folk tales are thoroughly German in spirit and imagination, and style of drawing. Oscar Pletsch, too, is remarkable for his feeling for village life and children, and many of his illustrations have been reproduced in this country. More recent evidence, and more directly in the decorative direction, of the vigour and ornamental skill of German designers, is to be found in those picturesque calendars which

Fig. 13.—Heywood Sumner. Heading for "English Illustrated Magazine."

come from Munich, and show something very like the old feeling of Burgmair, especially in the treatment of the heraldry.

I have some pages here from several of my own books. My own poem of the "Sirens Three," which is being in some measure influenced by the series of Omar Khayyam, may not inappropriately be shown here perhaps. Then the others which follow serve at least to show the direction in which I have myself aimed in the decoration and illustration of books, and in the treatment of the page as a whole, if I have not always succeeded to my own satisfaction.

The facile methods of photographic-automatic reproduction certainly give an opportunity to the designer to write out his own text in the character that pleases him, and that accords with his design, and so make his page a consistent whole from a decorative point of view, and I venture to think when this is done a unity of effect is gained for the page not possible in any other way.

Indeed, the photograph, with all its allied discoveries and its application to the service of the printing press, may be said to be as important a discovery in its effects on art and books as was the discovery of printing itself. It has already largely transformed the system of the production of illustrations and designs for books, magazines, and newspapers, and has certainly been the means of securing to the artist the advantage of possession of his original, while its fidelity, in the best processes, is, of course, very valuable.

Its influence, however, on artistic style and treatment has been, to my mind, of more doubtful advantage. The effect on painting is palpable enough, but so far as painting becomes photographic, the advantage is on the side of the photograph. It has led in illustrative work to the method of painting in black and white, which has taken the place very much of the use of line, and through this, and by reason of its having fostered and encouraged a different way of regarding nature—from the point of view of accidental aspect, light and shade, and tone—it has confused and deteriorated, I think, the faculty of inventive design, and the sense of ornament; having concentrated artistic interest on the literal realisation of certain aspects of superficial facts, and instantaneous impressions instead of ideas.

This, however, may be as much the tendency of an age as the result of photographic invention, although the influence of the photograph must count as one of the most powerful factors of that tendency. Thought and vision divide the world of art between them—our thoughts follow our vision, our vision is influenced by our thoughts. A book may be the home of both thought and visions. Speaking figuratively in regard to book decoration, some are

FIG. 14.—FRONTISPIECE. GRIMM'S HOUSEHOLD STORIES, CRANE EDITION. *Macmillan*, 1882.

content with a rough shanty in the woods, and care only to get as close to nature in her more superficial aspects as they can. Others would surround their house with a garden indeed, but they demand something like an architectural plan. They would look at a frontispiece like a façade; they would take hospitable encouragement from the title-page as from a friendly inscription over the porch; they would hang a votive wreath at the dedication, and so

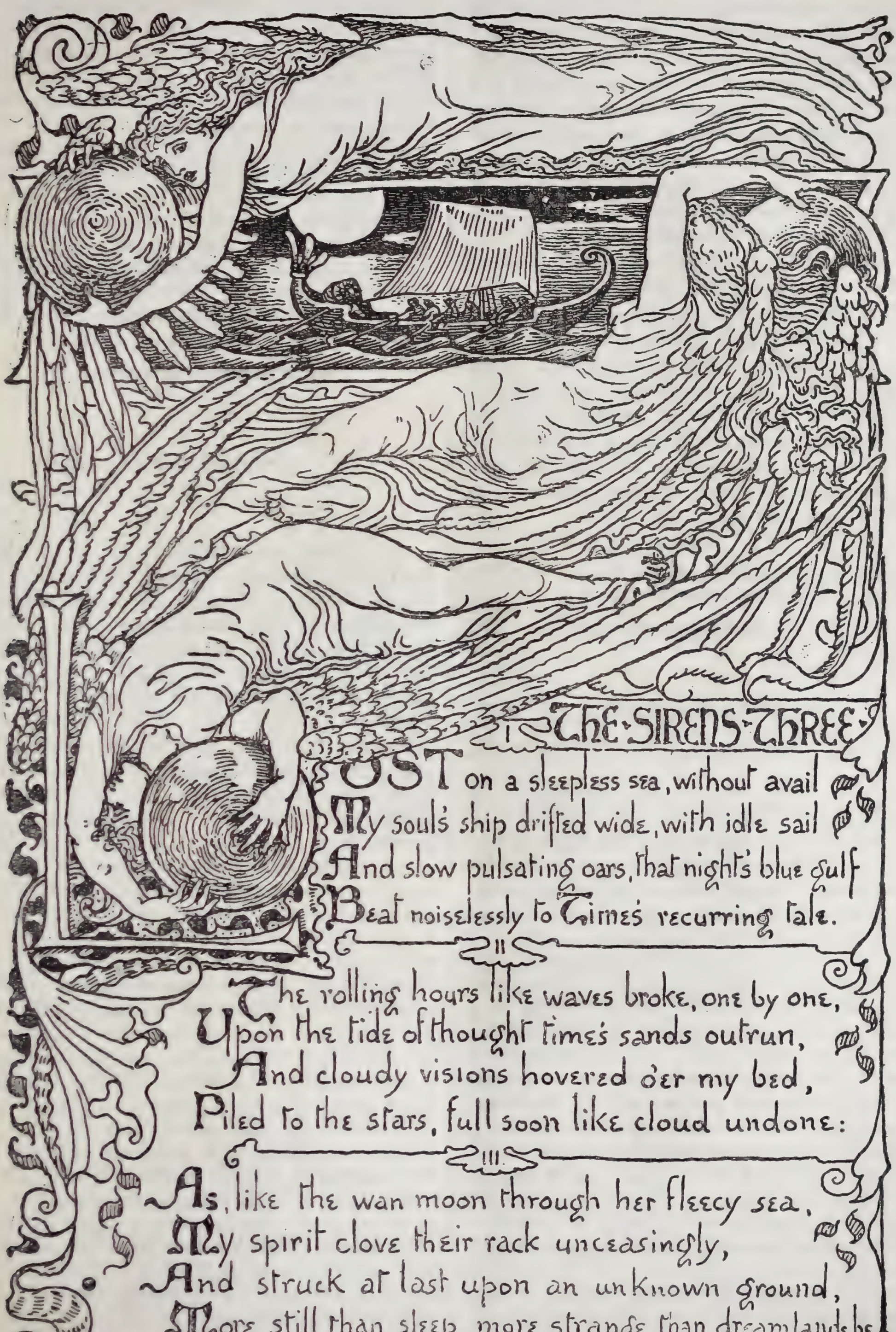


FIG. 15.—OPENING PAGE. "THE SIRENS THREE." WALTER CRANE. *Macmillan*, 1886.

pass on into the hall of welcome, take the author by the hand and be led by him and his artist from room to room, as page after page is turned, fairly decked and adorned with picture, and ornament, and device; and finding it a dwelling after his desire, the guest is content to rest in the ingle nook in the firelight of the spirit of the author or the play of fancy of the artist; and, weaving dreams in the changing lights and shadows, to forget life's rough way and the tempestuous world outside.

My best thanks are due to the help of various friends in regard to obtaining illustrations for these lectures. To Mr. Thomas Armstrong and Mr. Griggs; to Messrs. Dalziel Brothers; to Mr. William Morris; and to Mr. Emery Walker for his enthusiastic and valuable assistance in many ways, as well as for the magnificent series of slides he has made for me through his assistant, Mr. Pellatt; and lastly to my audience for their patient and sympathetic hearing.

The blocks for Figs. 11, 13, 14, 15, have been kindly lent by Messrs. Macmillan and Co.

Miscellaneous.

THE ORANGE TRADE IN VALENCIA.

Among the principal articles cultivated in the province of Valencia, the orange, for export, is the most important. Consul Merten says that the orange industry in the province is a very old one. The fruit was shipped in former years to the neighbouring French ports only in small coasting vessels. The export of such perishable fruit to distant countries commenced only after the year 1855, when steam navigation became more general, and this gave great impetus to orange culture. An average crop now amounts to 3,000,000 cases. Oranges shipped to foreign countries are wrapped in white or coloured tissue paper, which is mostly imported from France. The packing in cases varies according to the country to which the fruit is to be shipped. For instance, to England it is packed in cases containing 420 oranges, 76 kilogrammes in weight, and from 96 to 99 centimetres long, and in cases with 490 oranges, 70 kilogrammes in weight, and 90 to 92 centimetres long; to the United States in cases with 420 oranges, 80 kilogrammes in weight; to Holland and Germany in cases with 420 oranges; to France in cases with 240, 312, 420, and 490 oranges. Oranges are also sent in bulk, by rail, in great quantities to France. The pine trees grown in Spain furnish the timber for making the cases, and costs, ready sawn, from 10d. to 1s. the case. The export from Valencia amounted, in 1877, to 800,000 cases, in 1881 to 1,144,000 cases, in 1885, to 2,400,000, in 1887 to 2,000,000, and in 1888 to 1,500,000 cases. The falling off in the trade in 1887 and 1888 was due to fewer shipments to the United States, on account of the Florida supply. It is expected that in a short time the United States will cease to buy oranges from Spain. Germany has lately become a much larger customer of Spain, owing to the establishment of fruit auctions at Hamburg. Formerly the imports into that country from Spain were but a few thousand cases annually, whereas they now reach 150,000 cases. The cost price of a case containing 420 oranges amounts to from 6s. 3d. to 7s. 3d. free on board at Valencia.

Obituary.

W. PITMAN.—Mr. William Pitman, member of the Common Council, died on Wednesday, 23rd ult., at his residence, Kingsmead-house, Dartmouth-park-hill, in the 67th year of his age (having been born at Bath in 1823). He was elected a member of the Society of Arts in 1865, and on March 16th, 1870, he read a paper before the Society on "Surface Decoration."

W. WESTGARTH. — Mr. William Westgarth died at No. 10, Bolton-gardens, South Kensington, on Monday, 28th ult. He was born in Edinburgh, on June 12, 1815, and after a training in mercantile pursuits he proceeded to Australia, in 1841. He soon acquired a leading position amongst the commercial community of Melbourne, and for a time he was a member of the Victoria Legislature. In 1854, he returned to London, but continued his connection with the colony, and he wrote several works on Australia. Mr. Westgarth was well known to the members of the Society by his liberal offer of £1,200 for essays upon the construction of dwellings for the poor of the metropolis, and for plans for reconstructing Central London. Prizes were awarded to the amount of £600, in three prizes of £100 each, three prizes of £50 each, and six prizes of £25 each, and the three essays which gained the £100 prizes were published in a volume in 1886, with some introductory remarks by Mr. Westgarth. Mr. Westgarth was deeply interested in the subject for the advancement of which he offered these prizes, and on February 6th, 1884, he read a paper on the "Sanitation and Reconstruction of Central London," in which he explained his views on the subject of the improvement of the heart of London. He had previously (May 10th, 1881) read a paper before the Foreign and Colonial Section on the "Trade Relations of the Colonies and the Mother Country."

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FRIDAY, NOVEMBER 8, 1889.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

ARRANGEMENTS FOR THE SESSION.

The First Meeting of the One Hundred and Thirty-sixth Session of the Society will be held on Wednesday, the 20th November, when the Opening Address will be delivered by the DUKE of ABERCORN, C.B., Chairman of the Council. Previous to Christmas there will be four Ordinary Meetings, in addition to the Opening Meeting. The following arrangements have been made :—

NOVEMBER 20.—Opening Address by the DUKE OF ABERCORN, C.B., Chairman of the Council.

NOVEMBER 27.—J. HALL GLADSTONE, Ph.D., F.R.S., "Scientific and Technical Instruction in Elementary Schools." The Right Hon. A. J. MUNDELLA, M.P., in the chair.

DECEMBER 4.—ARMAND RUFFER, M.A., M.D., "Rabies and its Prevention."

DECEMBER 11.—H. TRUEMAN WOOD, M.A., Secretary to the Society, "The Paris Exhibition." SIR PHILIP CUNLIFFE-OWEN, K.C.B., K.C.M.G., C.I.E., in the chair.

DECEMBER 18.— SIR ROBERT RAWLINSON, K.C.B., "London Sewage."

Papers for which no dates have as yet been fixed :—

"The Chemin de Fer Glissant, or Sliding Railway." By SIR DOUGLAS GALTON, K.C.B., D.C.L., F.R.S.

"Modern Improvements in Facilities for Railway Travelling." By GEORGE FINDLAY, General Manager London and North-Western Railway.

"Commercial Geography." By J. S. KELTIE.

"The Relation of the Fine Arts to the Applied Arts." By E. C. ROBINS.

"Ocean Penny Postage and Cheap Telegraph Communication between England and all Parts of the Empire and America." By J. HENNIKER HEATON, M.P.

"The Industrial Arts of Japan." By A. LASENBY LIBERTY.

"The Records of the India-office." By FREDERICK C. DANVERS.

"Precious Stones at the Paris Exhibition." By H. TEMPLE ELLICOTT.

"Recent Progress in British Watch and Clock Making." By J. TRIPPLIN.

FOREIGN AND COLONIAL SECTION.

The meetings of this Section will take place on the following Tuesdays, at Five o'clock :—

January 21; February 18; March 18; April 22; May 6, 20.

INDIAN SECTION.

The meetings of this Section will take place on the following Fridays, at Five o'clock :—

January 17; February 7, 28; March 14; April 18; May 16.

APPLIED ART SECTION.

The meetings of this Section will take place on the following Tuesday evenings, at Eight o'clock :—

January 28; February 11; March 4, 25; April 15; May 13.

CANTOR LECTURES.

The following Courses of Cantor Lectures will be delivered on Monday evenings at Eight o'clock :—

WILLIAM JAGO, F.C.S., F.I.C., "Modern Developments of Bread Making." Four Lectures.
November 25; December 2, 9, 16.

Prof. SILVANUS P. THOMPSON, "The Electromagnet." Four Lectures.
January 20, 27; February 3, 10.

THOMAS BOLAS, F.C.S., "Stereotyping." Three Lectures.
February 17, 24; March 3.

Prof. A. H. CHURCH, "Some Considerations concerning Colour and Colouring." Three Lectures.
March 17, 24, 31.

RICHARD BANNISTER, "Sugar, Tea, Coffee, and Cocoa, their Origin, Preparation, and Uses." Four Lectures.
April 28; May 5, 12, 19.

JUVENILE LECTURES.

Two Juvenile Lectures on "The Story of a Flame," will be given by Professor VIVIAN B. LEWES, on Wednesday evenings, January 1 and 8, 1890, at Seven o'clock.

Miscellaneous.

*MEMORANDUM ON EXHIBITIONS HELD IN GREAT BRITAIN AND IRELAND.**

By the Secretary of the Society of Arts.

The following particulars concerning International Exhibitions held in Great Britain and Ireland have been prepared, by instruction of the Council of the Society of Arts, in response to a request of the Secretary of State for Foreign Affairs. They have been put in as summarised a form as possible, only those points of information having been noted which would appear to be specially useful to those having in view the organisation of a new exhibition, such as the main items of expense, revenue, number of visitors, &c. The first part of the memorandum deals with exhibitions held in London, the second with provincial exhibitions.

Reports are in existence giving detailed information about several of the exhibitions referred to. These reports should be consulted for full particulars of the organisation adopted, cost incurred, and success attained in each case. Special reference should be made to the reports of the Great Exhibitions of 1851 and 1862; that on the Colonial and Indian Exhibition of 1886; and that on the Manchester Exhibition of 1887. Much useful information will also be found embodied in the official records of the Sydney (1879) and Melbourne (1880) Exhibitions. Detailed reports on the London Health (1884) and Inventions (1885) Exhibitions were not published, but much information can be gathered from the published balance-sheets.

I.—London Exhibitions.

The first Great Exhibition of 1851 was publicly proposed by Prince Albert, at a meeting of the Society of Arts of London, on the 30th of June, 1849. A Royal Commission was appointed on the 3rd of January, 1850, and the building opened May 1st, 1851. It covered 20 acres, its greatest length being 1851 feet.

The total receipts amounted to £506,243, of which £186,000 was surplus profits. This total was made up of £423,792 for admissions, £67,896 subscriptions, together with payments for the refreshment contract, &c. There was no guarantee fund, the money subscribed providing the funds required before revenue began to come in from the admissions. As there were 6,039,195 visitors, the amount received at the doors represented about 1s. 5d. a head. The buildings cost £169,998, maintenance and police £24,524, personal services £67,309. The prices of admission were 5s., 2s. 6d., and 1s.; there were also two days at £1. Though there were 27 5s. days and 30 2s. 6d. days, nearly four-and a-half of the six million visitors paid their shilling at the doors.

There were three secretaries of the Commission, but the principal part of the work was carried out by an executive committee, of which the most active members were Mr. (afterwards Sir Henry) Cole, and Mr. (afterwards Sir Wentworth) Dilke.

The system of jury awards was initiated at this exhibition, there being three classes of awards—1st, Council Medal; 2nd, Prize Medal; 3rd, Honourable Mention. Of the first, there were awarded 171; of the second, 2,954; of the third, 2,123. The juries were international.

The very careful jury system organised for this exhibition has received for succeeding exhibitions various modifications, but its main principles have remained unchanged, wherever awards have been made.

The number of exhibitors was 13,937; British 6,861, colonial 520, foreign 6,556.

At the close of the exhibition the Royal Commission was made permanent, and the surplus funds (£186,000) invested in land at South Kensington. Various public buildings have been erected on the Commissioners' estate, the profits from which have been and still are devoted to the promotion of science, art, and education.

Full details of the finances, organisation, &c., are given in the First Report of the Commission, issued in 1852. The reports of the juries were issued separately.

The Exhibition of 1862, like that of 1851, was originated by the Society of Arts. It was held in buildings erected for the purpose on the estate of the 1851 Commissioners,

* This memorandum was prepared by the instructions of the Council, in consequence of a request from the Secretary of State for Foreign Affairs, who had been applied to by the American Minister for information on the subject of international exhibitions in the United Kingdom. Mr. Lincoln had been moved to apply for the information by the Mayor of Chicago, acting on behalf of the committee who are endeavouring to arrange for the holding of the proposed United States Exhibition of 1892 in that city.

some of the buildings being permanent, and having since served for other purposes, notably for later exhibitions on the same spot. The organisation was very similar to that of its predecessor, a Royal Commission being appointed for it.

A guarantee fund of £400,000 was raised by the Society of Arts before any other steps were taken for the organisation of the exhibition. The total receipts were £459,631. This amount was insufficient to meet the outgoings, and, in order to avoid a call upon the guarantors, the contractors, Messrs. Kelk and Lucas, reduced their claims by about £65,000, and Mr. (afterwards Sir John) Kelk made a donation of £11,000 to the funds. In consideration of the abatement the contractors took over the whole of the property of the Commission. The admissions amounted to £408,530, the refreshment contract to £29,285. The chief items of expenditure were—buildings, £329,001; roads, £13,358; salaries, £45,778; police, £19,435. There were 6,211,103 visitors, and they paid a little less per head than those in 1851, viz., 1s. 4d.

The exhibition suffered a great deal from the death of Prince Albert, which took place in the December of 1861. The fact of its being held during a season of national mourning was quite sufficient to account for its want of financial success. It was opened on the 1st May and closed the 15th November, 1862.

The total area of the building was 1,291,127 square feet. There were 28,653 exhibitors, of whom 16,456 were foreign.

As before, jury awards were made. A single class of medal only was given, but a large number of honourable mentions were added by the juries. The medal itself was of bronze. The number of medals voted was nearly 7,000, with about 5,200 honourable mentions.

A very full report of the proceedings of the Commission was published in 1863. The jury reports were published in a separate volume by the Society of Arts.

A proposal to hold in 1871 a third great exhibition in London did not meet with favour, and instead a suggestion put forward by Mr. Cole for a series of annual international exhibitions was adopted. The series was intended to last over a period of ten years, in accordance with the following classification:—

1871.—Pottery of all kinds; Woollen and Worsted Fabrics; Educational Works and Appliances.

1872.—Cotton; Jewellery; Musical Instruments; Paper, Stationery, Printing.

1873.—Silk and Velvet; Steel, Cutlery, and Edge Tools; Surgical Instruments and Appliances; Carriages; Substances used as Food; Cooking and its Science.

1874.—Lace, hand and machine made; Civil Engineering, Architectural and Building Contrivances and Tests; Leather, including Saddlery and Harness; Artificial Illumination by all Methods, Gas and its Manufacture; Bookbinding.

1875.—Woven, Spun, Felted, and Laid Fabrics (when shown as specimens of Printing or Dyeing); Horological Instruments; Brass and Copper Manufactures; Supply of Water.

1876.—Works in Precious Metals and their imitations; Photographic Apparatus and Photography; Skins, Fur, Feathers, and Hair; Agricultural Machinery and results; Philosophical Instruments, and processes depending upon their use; Electricity.

1877.—Furniture and Upholstery, including Paper Hangings and Papier-Mâché; Health — Manufactures, &c.

1878.—Tapestry, Embroidery and Needlework; Glass; Military Engineering, Armour and Accoutrements, Ambulances, Ordnance and Small Arms; Naval Architecture—Ships' Tackle; Heating and Combustion.

1879.—Matting of all kinds, Straw Manufactures; Flax and Hemp; Iron and General Hardware; Dressing Cases, Travelling Cases, &c.; Horticultural Machinery and Products; Magnetism.

1880.—Chemical Substances and Products, and experiments, Pharmaceutical Processes; Articles of Clothing; Railway Plant, including Locomotive Engines and Carriages.

The 1851 Commissioners guaranteed a sum of £100,000, the buildings remaining from the 1862 Exhibition were assigned for the annual series, and in accordance with the programme the first exhibition was opened in 1871. It attracted 1,142,154 visitors, and was a moderate financial success, but its immediate successors were less fortunate, and after the fourth, the non-success of the scheme was admitted, and the series was brought to an end.

Though these exhibitions were entitled international, the contributions from foreign countries were not very considerable.

No jury awards were made; a commemorative medal was given to each exhibitor.

That the idea of a series of exhibitions limited to specified arts and industries was a good one, was proved by its success a dozen years later, but the first attempt broke down in practice from various causes.

It was renewed under better auspices, and with conspicuous success in 1883, in which year another series of international exhibitions

was commenced in the same locality as in 1871, viz., on the estate of the 1851 Commissioners at South Kensington.

The first of these was the Fisheries Exhibition in 1883, proposed by and carried out under the active management of Mr. (now Sir Edward) Birkbeck. This was the outcome of a Fisheries Exhibition which had been held at Norwich, the promoters of which took up the idea of holding a similar exhibition in London. It was not under the authority of the Government, though the Prince of Wales was President, and the Government appointed Commissioners to make the jury awards, and treated its correspondence as official.

Only a small portion of the buildings erected in 1862, and employed for the 1871 series, were now available, the greater part having been utilised by the Science and Art Department for certain of their scientific collections, and for other purposes. It was therefore necessary to erect buildings of a temporary character. Those set up in the first instance for the Fisheries were afterwards enlarged, and added to for its successors. They were all of the cheapest possible construction, though admirably suited for their purposes.

The buildings were lighted by electricity, and were opened at night. Though this was not the first experiment of evening opening (which was tried at Dublin in 1865) it was the first on a large scale.

The Fisheries Exhibition was credited with a gross receipt of £162,903, of which £117,869 was obtained by the admission of 2,703,051 visitors (about 10d. each), and £8,702 was subscribed. But over £11,000 of this total amount was rent charged against the exhibitions which succeeded the Fisheries. The Fisheries buildings cost £44,238; their electric lighting, £10,397; salaries and wages, £14,098 (including police); publications, £17,399; conferences, juries, and jury awards, £11,288; advertising, £11,045; music, £5,255; gardens, £3,740. The surplus at the close was £14,752.

At the closing ceremony of the Fisheries Exhibition, the Prince of Wales suggested that the series should be continued by holding in 1884 a Health and Education Exhibition; in 1885, an Inventions and Music Exhibition; and in 1886, an Exhibition illustrative of the products of the British Colonies and of the Indian Empire. This scheme was carried into effect. For each exhibition a guarantee fund was subscribed before it was opened. For the Health and Inventions Exhibitions Executive Councils were appointed, of each of which the Prince of Wales acted as president. Like the Fisheries, these had no connection with the Government, the only assistance it rendered being that the Health Exhibition, like the Fisheries, was given free postage, though this privilege was not accorded to its successor.

The Health Exhibition contained illustrations of sanitary science in all its applications, and of education in every grade. A most important feature of it, as of the Fisheries, was the garden, which was illuminated every evening. It was at the Health Exhibition that illuminated fountains were first shown. Another novel and very popular feature was a reproduction of an old London street in the grounds. This idea of reproducing typical examples of mediæval domestic architecture was adopted in several later Exhibitions—Edinburgh, Manchester, and Glasgow, as well as in the Paris Exhibition, where an old Cairo street is represented.

The Royal Albert Hall, a building capable of seating 8,000 persons, was practically included in this and the succeeding exhibitions, and served for large assemblages, musical entertainments, &c.

The Health Exhibition had a total receipt of £237,048, of which £178,509 was derived from 4,153,390 visitors (about 10d. each). Donations amounted to £11,824. £12,023 was merely a nominal asset, since it represented an amount due from the Inventions for buildings and plant, but remitted. New buildings, including Old London, cost £47,045; electric lighting, £23,140; rent, £16,888; and rates and taxes, £1,573. Salaries and wages, £21,987; publications, £15,902; juries and conferences, £7,832; advertising, £15,764; music, £14,181; gardens and illuminations, £7,611. The Health surplus was £15,580.

The nature of the Inventions Exhibition is sufficiently indicated by its name, though it is to be remembered that it contained a second division—Music and Musical Instruments. An important part of this division consisted of a collection of old musical instruments. The garden illuminations were for the first time electrical, small incandescent lamps of various colours being used. The exhibition was financially less successful than its predecessor. Its total receipts were £196,312, of which £149,825 were obtained from the payments of 3,760,581 visitors. £600 were received from subscriptions. The total payments amounted to £214,403, leaving

a deficit of £18,089, which was made up by absorbing the surplus of the Health Exhibition, and by a grant from the funds of the Colonial Exhibition. The main items of disbursement were as follows:—Buildings, £30,778; electric light, £37,551; salaries and wages, £25,064; publications, £10,829; jury awards, £5,187; rent, £4,126; rates and taxes, £3,430; postage, £3,661; advertising, £14,940; music, £17,039; gardens and illuminations, £15,964; motive power (machinery), £14,848.

The deficit is easily accounted for by the amount of the second and of the last three items. A large amount of machinery was shown; the electric garden illumination was costly; and large sums were expended on the admirable musical entertainments given in the gardens and in the Albert Hall.

That the receipts from this exhibition were smaller than from the Health Exhibition was attributed to the wet weather which prevailed during part of the time it was open.

All these exhibitions were distinctly international, though the contributions from foreign countries varied much in amount and importance. The most important foreign exhibits were in the Fisheries Exhibition and in the educational division of the Health.

In all cases the juries were international, and the medals were gold, silver, and bronze, each medal being accompanied by a diploma. In the Health and Inventions the British jurors were, in the first instance, nominated by the exhibitors, the foreign jurors being appointed by their respective commissions.

The Colonial and Indian Exhibition, held in 1886, was on a different basis to its predecessors. It was under a Royal Commission, the president of which was the Prince of Wales, and the secretary, Sir Philip Cunliffe-Owen.

With but few exceptions of any importance all the colonies and dependencies of Great Britain took part in it:—Canada, New South Wales, Victoria, South Australia, New Zealand, the Cape, the West Indies, &c. Our great Indian Empire also contributed very largely.

Though it was not therefore an international exhibition, the organisation necessary was on the same scale, and of the same character, as would be required for an international exhibition.

The resources required were, in the first instance, provided by a guarantee fund of £219,430.

As regards finances, the total receipts of the exhibition amounted to £249,861, the total expenditure to £215,218, thus leaving a surplus of £34,642. £205,840 were received for the admission of 5,550,745 visitors (about 8·7d. per head). Royalties and concessions brought in £24,250; sales of fittings and exhibits, £11,760.

The buildings cost £36,228, and rent £17,978; salaries and wages, £38,107; electric lighting of buildings, gardens, and fountains, £32,787.

There were no jury awards, but a commemorative medal and diploma were presented to each exhibitor.

In all these exhibitions entrance was obtained by (i.) payment at the doors, (ii.) tickets purchased beforehand, (iii.) season tickets, (iv.) passes to exhibitors and executive. The price of admission was 1s. each day, except on Wednesdays, when it was 2s. 6d., but the purchaser of a combined railway and entrance ticket paid considerably less than the full price in addition to the railway fare. It should be mentioned that at none of the above exhibitions were exhibitors charged for space.

In addition to the exhibitions above mentioned, of course many special exhibitions have been held in London. Prominent among these were the Loan Collection of Scientific Apparatus (1876), and the Smoke Abatement Exhibition (1882). Both these were held at South Kensington. The former was under the authority of the Science and Art Department, and was thoroughly international, for the most interesting and valuable examples of scientific apparatus, historical and modern, were collected from every part of Europe. The latter was organised by a private committee; its object was to inform the public as to the best means of obtaining and utilising heat without vitiating the atmosphere. In connection with the Smoke Abatement Exhibition an extensive series of tests of domestic fire-grates was made, and on these the awards of medals given were based.

Exhibitions of various characters, which have been in the nature of commercial enterprises, have also been held in the Crystal Palace, the Alexandra Palace, the Agricultural-hall, Islington, and elsewhere. Nor would the list of London exhibitions be complete without reference to the American Exhibition (1887) at Earl's-court, with its successors the Italian Exhibition (1888),

and the Spanish Exhibition (1889), or to the Irish Exhibition (1887) at "Olympia," Kensington, and the Danish Exhibition (1888) at the Horticultural-gardens.

II.—Provincial Exhibitions.

Besides the London Exhibitions already referred to, a great number of exhibitions, most of them not international even in name, and probably none of them owing very much to foreign assistance, have been held in different parts of Great Britain. The first of these was at Cork, in 1852, and the next at Dublin in 1853. Dublin also had exhibitions in 1865 and 1872. With these exceptions, until the very successful exhibitions at South Kensington attracted public attention, no provincial exhibitions of importance appear to have been held in this country. The magnificent Art Treasures Exhibition of 1857 in Manchester, though its special nature takes it outside the scope of this notice, may just be mentioned. It produced a revenue of £13,520, the number of admissions was 1,336,715. There have also been other Fine Art Exhibitions, but none so good or so successful. In 1884 an Exhibition of Forestry was held at Edinburgh. In 1886 an International Shipping Exhibition was held in Liverpool, followed by a second General Exhibition in 1887. Financially neither of these was very successful. There were also exhibitions, some of which bore the title of international and others not, at Newcastle and Edinburgh in 1886, at Manchester in 1887, and at Glasgow in 1888. These last four exhibitions, though they contained comparatively few contributions from foreign countries, were all on a scale entitling them to rank with any except the great Exhibitions of London, Paris, Vienna, and Philadelphia. The attendances at Manchester and Glasgow were higher than at any of the recent London exhibitions, and not far behind those of the 1851 and 1862 Exhibitions. Much experience was gained at them, and they certainly should not be overlooked by those whose task it may be in the future to organise an international exhibition in any other country.

A few details of these exhibitions may now be given.

Cork.—At Cork, in 1852, there were 74,095 visitors. The exhibition was held in the Corn Exchange of the City, and was on a small scale. It was confined to Irish industries alone.

Dublin.—Of the Dublin Exhibitions the first, in 1853, was due to the liberality of Mr. William Dargan, who contributed a sum of not less than £80,000. A chief feature of the exhibition was the fine collection of Irish antiquities which it contained. It does not appear to have been of a genuine international character. The exhibition held in the same city, in 1865, was also aided by the liberality of a prominent citizen, Sir Benjamin Guinness. There were over 900,000 admissions. This was the first exhibition at which the experiment was tried of opening in the evening. At the third exhibition in Dublin, in 1872, there were 420,000 visitors. This did not profess to be international, and indeed it was almost wholly Irish.

Liverpool.—The first Liverpool Exhibition, in 1886, was, as its name—The International Shipping Exhibition—implied, devoted to maritime matters. The total receipts were £131,032, the expenditure £150,167. The deficiency of £19,135 was made up from the guarantee fund of £87,474. There were 2,468,098 visitors, who paid amongst them £102,711. The buildings covered 58,000 square yards, and cost about 17s. per square yard. Financially, the second Liverpool Exhibition, in 1887, was less successful even than its predecessor, for its promoters had to call up the whole of their guarantee fund of £34,289 to cover the loss they had made. This exhibition had a large amount of contributions from the Colonies. At both exhibitions diplomas, supposed to represent gold, silver, and bronze medals, were awarded.

Newcastle.—The Mining, Engineering, and Industrial Exhibition at Newcastle, in 1886, was visited by 2,092,273 persons. No report or financial statement has been published, certain matters being still (October, 1889) under dispute, but the exhibition was stated to have been a financial success.* Its most important feature consisted of the mining exhibits; the illustration of shipbuilding was also very fine. The guarantee fund amounted to £35,000. Though called international, there do not seem to have been any foreign exhibitors. The charge for space averaged 2s. 6d. per square foot.

Edinburgh.—The total receipts at the 1886 Edinburgh Exhibition amounted to £110,882, of which £83,040 was from admissions, £15,309 from rent of exhibitors' spaces, and £4,560 from refreshment contracts. The total ex-

* Since the above was written an announcement has been published that the surplus amounted to £4,388.

penditure was £105,326, so that there was a surplus of £5,555. The buildings cost £39,869, salaries and wages £10,896, electric lighting £6,854. The number of visitors was 2,769,632. Jury awards were made, but no actual medals were given. The exhibition was general in its character. There were few if any foreign exhibitors. The reproduction of a portion of Old Edinburgh in the grounds was a very popular and attractive feature. The buildings covered 39,950 square yards.

Manchester.—In 1887 Her Majesty's Jubilee was celebrated in Manchester by the holding of an Exhibition of Arts, Science, and Industry, which was not specially international, and had no foreign sections. It was visited by 4,765,137 persons. The receipts from admission amounted to £96,969. The total receipts were £268,290, the surplus being £46,977. A charge for space of 2s. 6d. per square foot was made to exhibitors, the receipts from this source being £22,280. £52,380 were received from royalties and concessions, of which £44,016 were paid by the refreshment contractors. The sale of the buildings, &c., realised £12,540. The subscriptions to the guarantee fund amounted to £115,307. From amongst the guarantors a council was formed, who had the disposal of the surplus. The exhibition was regarded as extremely successful, a principal feature in connection with it having been the magnificent collection of English pictures painted within the last fifty years.

It was situated in the neighbourhood of Old Trafford, on the outskirts of Manchester, and had easy communication by cab, tram, and railway with the city. It was at first intended to award medals, but after much consideration it was determined that there should be no awards of any sort whatever. This decision was cordially approved by the exhibitors, and is believed to have given general satisfaction.

Glasgow. — In 1888 an Exhibition of Industry, Science, and Art was held at Glasgow. This, though nominally international, did not contain any very important contributions from foreign countries. Like its predecessor in Manchester, it was very successful, both financially and as regards the number of visitors. The receipts from all sources amounted to £225,928, of which £162,933 were from admissions, and £43,952 from royalties and concessions. A charge of 2s. a foot for space made to exhibitors brought in £15,955. The lighting cost £9,972, the illuminated fountain £5,248. The music and other entertainments cost £19,747. The cost connected with the building and grounds amounted to £97,222. The balance of profit was £40,713. The number of visitors was 5,748,379.

As at Manchester, there were no jury awards, and it is not believed that any exhibitors were kept away by the fact.

The grounds surrounding the buildings were very extensive. The show of machinery was specially fine, as was also that of ship models. There was an Indian Court and a Canadian Court, but very few contributions from foreign countries.

To complete the record it may be worth while to mention the fact that many exhibitions of importance have been held in the British colonies, though any details about them would be outside the scope of this memorandum. Melbourne had exhibitions in 1854, 1861, 1872, 1875, 1880, and 1888. An intercolonial Exhibition was held at Sydney in 1870, and an international one in 1879. In 1883 an exhibition was held in Calcutta, and in 1877 one at the Cape of Good Hope.

Society of Arts, London,
October, 1889.

UNSANITARY BUILDINGS OF SUBURBAN LONDON.

Two years ago (*Journal* 1,823) reference was made to the vast amount of rebuilding then in progress or just being commenced in London, and a list was given of the more important clearances effected during the year by demolitions. Attention was also briefly drawn to the character of houses erected in new suburbs, a subject since again referred to (*Journal* 1,907). The great changes in the City have been omitted, as the new buildings there are not intended for habitations, and all improvements referred to have been regarded mainly from the sanitary aspects or that considered by the Royal Commission on the Housing of the Poor.

During the two years that have elapsed, rebuilding and the spread of new districts have brought about most striking changes. Never has the metropolis been in such a condition of rapid transition centrally, and of spread outwardly, as in the recent and present periods.

Charing-cross-road has now the appearance of an almost completed thoroughfare, and though parts of the northern side of Shaftesbury-avenue, not included in the demolitions, will before long be rebuilt on a scale corresponding with the new imposing and, in some cases ornate, buildings around, the work already done shows how completely the character of this part of London is changing. The famous slums

of the Seven Dials district no longer exist. The rebuilding of the other districts mentioned in the list has been accomplished,* and, concurrently with this, fresh clearances have been made. Clearances and rebuilding have also been commenced, and in some cases already completed, on various scales in Brixton, Kennington, Newington, Camberwell, Battersea, Southwark, Balham, Streatham, and other localities, that till not long ago remained as old centres of population quite distinct from London itself. All round the outer circle of London suburban building has progressed rapidly.

When an endeavour is made to take a widely comprehensive view of all these vast and important changes, so opposite in their character in different localities, and to estimate the probable effect of what is now being done on the sanitary conditions for the population of London in the near future, a broad but well marked line appears to distinguish the areas of rebuilding centrally from those of new building in the suburbs.

In the districts of rebuilding, large erections, substantial in structure, and imposing, whatever their style and material, by their dimensions, take the place of old houses of mean elevation, generally aged and worn to a stage of dilapidation, and frequently so neglected as to have reached the condition of being used only by those familiarised with overcrowded squalor. Standing in widened thoroughfares which are nearly all planted with trees, the new buildings, by the enduring materials employed in their frontage, give to the busy streets that look of prosperity which well accords with the position London holds as the greatest metropolis of the world. And sound durable material, so important for permanent sanitary work, is not confined to frontages. Even the blocks of "industrial dwellings," with no pretensions to architectural beauty, although generally brightened out of monotony by "window gardening," show how thought has been taken that artisans may find domicile in substantial and sanitary buildings that have at least stability, cleanness, and free breathing space clear of foul back yards or neglected gutters. Solidity and large size, with wide space and careful sanitary arrangements, are the characteristics common through all the districts of rebuilding.

Not only the designs but the materials used for the new buildings afford a striking contrast to those employed for the demolished. The sound, well made bricks are brought from different parts of the country, some from even the north of England. The local areas of brick earth of the better quality appear exhausted. The imported bricks are good and well made, and there is a wider range of colour —grey, cream, deep red, white (or a near approach to it), purple, and black. Much glazed brick, too, is used, especially of white, where reflected light is wanted. Many are moulded with patterns, and stucco seems almost entirely discarded. The greatly increased use of terra cotta is a marked feature. In plain moulding it is adopted for window and door jambs. With floral, classical, Italian, or grotesque designs it is introduced in columns, capitals, plaques, and even large slabs, thus meeting the requirements of removing the barrack-like monotony of plain brick frontages by durable and clean material in place of the crumbling and dirt-making compositions that had so largely crept into use. Columns for which stucco was thought sufficiently good are now of granite or other stone capable of high polish, while oolites and sandstones of fine texture are much more extensively used. Solid oak, beech, or mahogany have largely taken the place of painted deal in woodwork, and thick glass of large size has almost entirely superseded the use of small panes, except where employed for effect or privacy. With all these improvements in structural soundness, pipes, traps, and gullies connected with sanitary engineering are arranged so that they may be readily inspected and any defect remedied.

In the districts of new building the leading spirit appears to be the exact opposite to that which rules in rebuilding. No thought of solidity or durability, or even sound building, seems to be taken into consideration, and the leading characteristic is the use of common material for construction, with something not quite so bad to obtain a showy frontage. Lessons from experience gained in sanitation are neglected, and sanitary work is badly planned, and carried out with such poor materials that it is soon out of order.

Exception must, of course, be made of those districts where there are erected family residences standing in their own grounds. Whether the designs be stately, cosy, or fantastic, architects, sanitary experts, and good builders have, with sound and often costly material, combined to produce substantial houses. But taking the ring of building all round London, such residences form but an insignificant part of the whole, and are generally confined to a few localities. Small detached and semi-detached houses, too, on some estates are well built, though on others they are very bad.

It is the rows of thousands of small houses, bringing about suburban changes even more surprising than the changes in rebuilding, that are reproducing many of the structurally bad features of the old central houses that have been demolished.

While the rebuilding is familiar to those who move about in central London, few know much of the growing suburbs. To do so requires considerable leisure for visiting them section by section. A mere drive through any one of them does not afford opportunity for seeing the really weak character of the houses. They need to be visited on foot, with time to go over some of them before they are quite finished. A more complete and useful knowledge, from which safer inferences may be drawn, is to be had by watching the process of building all through from foundation to completion.

It is not in all respects that the suburbs are repro-

* The site of the slums around Chelsea market is now occupied by large dwellings.

ducing such evils as are being cleared from central London. The roads are wide, they are (at least to begin with) well paved, the houses have front and back ventilation, and are not high in relation to road width, there is a small garden space at the back for clothes drying, and generally a few square yards in front. The children, old enough to play in the street, have it almost to themselves, and pavement and roadway (often of gravel) are clean. Further, in favour of the new buildings they are erected from the first as dwellings to be let in lodgings—and so in conveniences differ from the old houses, which were at first either cottages in courts or family houses from two to four stories high. Were the new houses substantially built, their arrangements are such that they have much to commend them.

For example, a widely prevailing plan, with various modifications in details, is to build houses of four main rooms, with a kitchen and small room over it at the back. The kitchen, facing the passage and not extending the whole width of the house, leaves a yard on which the ground floor back window opens. The door to the room over is generally at the turn of the stairs, and then the kitchen is not so high as the main rooms. In a few houses, however, the stairs go straight up without a bend, and then all the rooms are of equal height. In a large number of cases the small room over the kitchen is fitted with a cooking-range and boiler, and water supply. The house then is adapted for two lettings, each of two rooms and a kitchen. A scullery with washing boiler is mostly built on to the lower kitchen. On some estates the six-roomed houses, of higher rental, have a combined w.c. and bath-room, and even some rows, planned on a larger scale, have a separate bath-room; but from the kind of fireplaces, cornices, &c., these are evidently designed for families where at least one servant would be kept. The houses so arranged that it is expected the wife would do all the work of one set of rooms far outnumber those where it is expected a servant would be kept. What is expected does not however always happen, for sometimes a family will occupy six rooms and keep two servants, while on the other hand sometimes a man and his wife and children will occupy the three ground floor rooms, and sub-let each of the three upper rooms separately. All the letting is by the week, and if they have the money people take just what they want. Such suburban rooms are much sought for when they are new. There are people so anxious not to "follow other people's dirt," as they express it, that one end of a row may be seen occupied before the other is finished. They have at first many attractions, and many of their arrangements are convenient improvements on old houses.

But they are not substantial.

The following outline description of how such houses are built is based on observations made in watching rows of them, in five districts, through the different stages of their construction. In four cases the building ground was approximately level, but in one it was at the base of a slope of about 20°, and almost always wet.

To begin with, the lines on which the walls were to be built were marked out by shallow trenches, the intermediate ground being generally left with its grass and sometimes puddles. The depth of the trenches differed, but it did not exceed two-brick thickness in one case, three in another, and four in the others. In these were laid the foundation bricks, which were of poor material and very inferior make. On them the commencement of the walls was carried up two courses of bricks, and then came the rafters, placed at intervals in another two or three courses. The ready-made door frames were then put up, and the ready-made window frames when the right height had been reached. As the building continued, the bricks were laid round the frame-work so as nearly as possible to touch. The bricks being very rough, the fitting was so inaccurate that light could be seen between them and the wood, often in eighth or quarter inch gaps, or more. Good bricks, which have smooth surfaces and are nearly rectangular, fit with but a small amount of fine mortar. But these bricks, motley in colour, of shades of yellow, red, and purple, coarsely porous in texture, very rough on their surfaces and irregular at their edges, needed much mortar to fill in the interstices between them as they were laid; and the mortar used was coarse and sandy. Perhaps a builder of good houses would hardly admit that mortar was a correct name for it.

When the bricklayers had sufficiently advanced, and the roofs and chimneys were being finished, the carpenters nailed down the thin planking for the floors, fixed the ready-made staircase, hand-rail, windows, and doors—all ready-made and brought on carts. Then the plasterers and "art decorators" proceeded to their work simultaneously with the plumbers.

Viewed only artistically, the frontage of a newly-finished row looks attractive. The bricks are treated with a wash that brings them to a uniform colour, the "pointing" of the mortar is in red, black, white, or some colour of strong contrast and sharply defined, the windows are large, the street door almost invariably has glass in it, stained or with a pattern, has often an "art knocker," and everything is done to give an air of bright cheerfulness. Inside, too, the moulded or polished fireplaces, the cornice and "centre flower" in the largest room, the art-paper and the paint, gives the impression of care in attention even to details. These details, however, are found to be ephemeral, and the permanent fact remains that the houses are structurally defective from the inferior materials of which they are built—bad bricks, bad mortar, and unseasoned wood.

The report of the Royal Commission of the Housing of the Poor—which took evidence five years ago—speaking of modern houses "run up for the working classes," said they were "often built of the commonest materials and with the worst workmanship. . . . . The old houses are rotten from age

and neglect. The new houses often commence where the old ones leave off, and are rotten from the first" (p. 12).

The suburbs are not alluded to anywhere in the report, and but passing reference is made to them in one or two cases in the evidence. But if "rotten" may be rightly applied to bricks that break with the tapping of an umbrella point, to mortar that crumbles to dust and is blown away by the wind, even the whole row of new suburban houses are "rotten from the first."

Whatever may be the excellence of technical training in brick-making, and in the composition of mortars and cements, it needs but an inspection of suburban building to see how small up to the present has been the practical effect of that training. Indeed, should any historian of the future express his opinion that the art of brick-making had seriously deteriorated in the Victorian period, and had sunk very low as compared with the time of Queen Anne, he could readily point to illustrations in abundance that would be held to support him. The experience of workmen is that to pull down a Queen Anne house is a "tough job," and quickly blunts their tools—the mortar and cement used being good to match the good bricks. Modern buildings come down with a run by just being touched—so they express it.

People who go into such houses as described are not long in finding out their weak points. It is during the alterations of weather in the first few months that mortar dries, expands, and contracts, and most readily begins to disintegrate. Small lumps of it fall down the chimney, the ceilings begin to crack and plaster falls, rains soak through the porous walls, the paper turns colour, and then in places drops. The dried plaster from the ceiling below blows through the cracks into the rooms above. The woodwork in drying warps and twists in various ways, and all sorts of fittings and fasteners go wrong and will not work without a strain—windows either stick or let in draughts, and so do doors. In cold weather nothing seems to fit to keep out the cold winds, or the dust that rises in eddies from the unsettled roads, mixed with crumbling mortar. It is curious to see how winds, frost, hot sun, and rains clear away the mortar as if it had been intentionally picked out.

In many sanitary inquiries reference is made to three distinctive classes of tenants. The criminally destructive, the mischievously or thoughtlessly destructive (mostly children or young lads), those who make feeble efforts to keep the place in order, and those who will be clean and tidy at whatever cost of labour. An ill-built, cold, draughty house that lets in dust with every wind is a tax to even a very energetic woman, when she has all household work, as well as mending, washing, marketing, and cooking. If she catch a cold, or fail in her usual strength, her will to work may easily fall below what she has to do. Many of these, houses though a shelter from the rain, soon become small shelter from the wind. It is in all sanitary conditions admitted that one of the first necessities for a well-cared for house is a sufficiently substantial building. Those who do not trouble about it, and are willing to put up with anything, are not the class of tenants good landlords care to have when they have any choice. But the "better class" of tenants soon get away from these "ramshackled buildings," as they call them. That "rougher lot," described in the Royal Commission evidence as always able to find money somehow or other, manage to get in. To judge of the future of such houses it is necessary only to look at similar ones only ten years old. Many rows of houses built at the beginning of the century are not in a worse state of dilapidation.

Five years ago it was stated by witnesses* that there are building bye-laws which are not put in force. Without a systematic inquiry in all districts it is impossible to say what now are or are not enforced. The inquiries of the Mansion House Council have not extended to the suburbs. But whatever may be the extent to which building bye-laws are enforced, the inference that would probably be drawn by those who examine suburban building operations is, that each man does that which is good in his own eyes. The question is a serious one, for it seems quite possible that what is being done at present is to remove badly-built houses and destructive and careless tenants from central London, and (at the cost of loss of green all round) to transfer them to an outer ring. To beautify central and spoil suburban London.

Speculating builders are now making the commencement of the sanitary history of the new suburbs. There was given before the Royal Commission much evidence on the effect of badly-built houses on the habits of the tenants. While some witnesses dwelt much on the good effects of sustained moral influences, it was also urged that damp, draughty, ill-built houses affect vitality and the energy to keep a set of rooms in homely order. The rough are "habituated to dirt," and it will "take two generations to change their habits."

Among the small amount of evidence given with regard to the suburbs was:—

(6085-6). The sanitary arrangements, and bad work and bad fittings, make the houses cold and draughty. "It is when they are unable to let to a better class of person that those who are not so particular come in, and new districts become just what many of the districts in the centre of London are."

W. S. M.

FOREIGN POPULATION IN FRANCE.

M. Victor Turquan, in an article published in the *Journal de la Société de Statisque de Paris*, says that

* See 6007, &c.; 6072, &c.; 6154. R. Com. Housing Poor.

for the first time, statistics have been prepared showing the births, deaths, and marriages of the foreign population of France, the population consisting for the most part of English, Germans, Belgians, Spaniards, Italians, and Swiss. The attention of the French Government was called to this subject when the results of the last census enumeration were made known, these results showing how great an increase has taken place in the number of foreigners inhabiting the country. Taking first the marriages, it appears that throughout the whole of France during the year 1888, 3,065 took place between foreigners themselves, 3,403 between women of foreign nationality and Frenchmen, and 4,840 between Frenchwomen and foreigners. The number of persons of foreign nationality therefore contracting marriages in France in 1888 amounted to 14,373. Of these, 7,905 were men, and 6,468 women; but, as is well known, the males very considerably exceed the females in the foreign population of France. In the case of the 6,130 foreigners who intermarried, 5,144 were of the same, and 986 only of different nationality, but other than French. Foreigners therefore most frequently marry persons of French nationality, or of the same origin. Finally, 8,243 persons of French nationality married foreigners, of whom 4,840 were women. Thus the number of women who have lost their French nationality is greater than that of those who have become Frenchwomen by marriage. Examining the question of the respective proportion of marriages for each of the principal nationalities, it will be found that out of every 100 marriages 96 are contracted between French men and women. More than half of the others, that is 57·5 per cent. are contracted between French people and foreigners. This proportion varies between 70 per cent. in the case of the English marriages, and 48·5 per cent. in the case of Spaniards. Out of 1,000 persons in France it is found that 14·6 were married during the year; this average falls to 12·8 for the entire foreign population, and in this same population has varied between 7 per 1,000 in the English colony, and 21·5 in the German. After the Germans it is the Swiss who marry the most frequently in France, the proportion being about 19 marriages to every 1,000 inhabitants of this nationality. It is, therefore, from the eastern portion of France that the infiltration is most felt, and this appears to be confirmed by the results of the last census, which showed that the greatest number of foreign births occurred in the east and north-east of France. The number of births among the foreign population amounted in 1888 to 29,105, of which 11,754 were among the Belgians, and 9,757 among the Italians. Taking the number of births to every 1,000 inhabitants, it appears that in 1888 the proportion for the whole of France was established in the ratio of 22·2; for the persons of French origin, 22·1; and for the foreigners of every nationality, 25·8. The latter, which is very much higher than the French birth-rate, is established as follows:—Proportion of births to every one thousand persons of English nationality, 13·1; Swiss, 21·6; German, 23·4; Spanish, 24.3; Belgian, 24·4; and Italian, 36·8. It is therefore among the Italians that the birth-rate is relatively highest. M. Victor Turquan states, that the lowness of the birth-rate among the English colony may be accounted for by the fact of their low marriage rate, and that many come to France to travel and amuse themselves, and not to settle down and marry there. In the published statistical returns, there is a distinction made between legitimate and illegitimate foreign births, and the number of the latter reported in France during the year 1888 is said to be very striking. The proportion of illegitimate births, taking all the nationalities together, is 15·4 per cent. of the total births. In this connection it is observed that the greater number of foreigners inhabit the northern and eastern parts of the country, where the number of births in this category is relatively high, and particularly in the large commercial and manufacturing centres, such as Paris, Lyons, Lille, and Marseilles. Out of every 100 total births, there are seven illegitimate births among the Spaniards, eleven Italian, thirteen Belgian, sixteen English, seventeen Swiss, and, finally, twenty-four German. In Paris itself these proportions were very much higher, for they were established at the rate of 38 per cent. English, 33 per cent. German, and 21 per cent. Swiss. In Paris the general proportion per 100 total births is from 24 to 25 illegitimate. The number of deaths occurring among foreigners of all nationalities in 1888 amounted to 17,971, and the number of births having been shown to be 29,105, this leaves for the foreign population an excess of births over deaths of 11,134. The mortality among foreigners in France is much lower than among the French themselves, the reason for this, according to M. Turquan, being that the adults are in very much greater number, and death spares these more than children and old people. The German population alone approaches the French very nearly in this respect. Of the 17,971 deaths of foreigners reported during the year 1888, there were 6,666 Belgians, 4,955 Italians, and 2,268 Germans. To every thousand of all ages existing, the proportion of deaths were as follows for each nationality:—German, 23; Italian, 19; Spanish, 18: Belgian, 14; English, 14; and Swiss, 13. The general average for France is 22 per 1,000 inhabitants. Deaths of females predominate among the Italians and Spanish, although women of these races are in the minority in France; while among the English, Belgians, Swiss, and particularly the Germans, far more men die than women; and yet at each census enumeration it is found that among the English and Germans there are more females than males. As pointed out above, there is an excess of 11,134 births over deaths among the foreign population of France, which shows a natural increase of 1 per cent. This increase is not the same for all nationalities, for example, the deaths slightly exceeded the births among the English, and the increase

of births over deaths was insignificant in the case of nationalities other than Belgian, Spanish, Italian, and Swiss. For the four latter the increase was as follows:—Belgian, 5,088 persons, on a total of 482,000, or 11 per cent.; Spanish, 512, on a total of 79,000, or 6·5 per cent.; Italian, 4,802, on a total population of 264,000, or 18 per cent.; and Swiss, 690 increase on a total of 79,000, or 8·7 per cent. The natural increase of the Italian population is particularly striking, as it is eighteen times greater than that of the French race, and twice as great as that of the Swiss or Spanish population. The Belgians, although exhibiting in France a birth-rate about equal to that in their own country, increase ten times more rapidly than the French. In conclusion, M. Turquan points out how conclusively these figures prove the necessity for France to leave her frontiers open, and to what extent the immigration and the assimilation which ensues, is useful in filling up the gaps in the French population, caused by the remarkably low birth-rate.

MINES OF BOLIVIA.

M. A. Carion, Belgian Consul General at Santiago, in the last report to his Government states that the soil of Bolivia contains antimony, sulphur, bismuth, cobalt, cinnabar, copper, iron, nickel, ochres, gold under different forms, silver, saltpetre, salt, &c. Discoveries of coal have lately been reported from Calacots and Achumani, which are situated at a litte distance from La Paz. Copper is frequently found under a form called *charqui*; this consists of sheets of copper similar in appearance to thin slices of sun-dried meat which is known as *charqui*, hence its appellation. Marble, and more particularly that transparent description resembling alabaster, and which is called *berenguelas*, is frequently found, as are also earths suitable for the manufacture of faïences, tiles, &c., also kaolin, mineral waters, &c. The principal copper mines are at Corocoro, these yield from 1,500 to 2,000 tons annually. In the Royal or Central Cordillera there are the silver mines of Esmoraco, Santa Isabel de Potosi, Chocaza, Huanchaca, Potosi, Colquechaca, Portugalete, Poopo, Huanuni, Antequera, Colquiri, Illemani, Guania, and others. In the mountain chains of Lipez there are the mines of San Antonio, Ascotan, &c. Tin often accompanies silver in these various mines. Thus at Potosi there is a rich vein known under the name of La Bel Estano; at Oruro also there is one known as San Louis, and there are others at Huanuni, Colquiri, and elsewhere. The silver mines of Bolivia may be classed as follows:—(1) Huanchaca, the production of which is steadily increasing; (2) Colquechaca; (3) Oruro; (4) Portugalete; and (5) Potosi.

General Notes.

Gas Consumption in France.—The *Journal de la Société de Statistique de Paris* says that at the Exhibition of 1878 it was established that the gas consumption of Paris, which amounted in 1872 to 260,000,000 cubic metres in 530 towns, with an aggregate population of 8,757,600 souls, has risen in 1878 to 382,000,000 metres in 687 towns, with a population of 9,943,400, thus corresponding, with escape, to a production of 430,000,000 cubic metres. In six years, therefore, there was an increase of 25 per cent. in the number of towns, of 13·5 per cent. in the population, and 31·4 per cent. in the production. As regards the latter, it amounted in 1878, as stated above, to 430,700,000 cubic metres, in 1880 to 507,800,000, in 1885 to 589,100,000, in 1886 to 600,700,000, in 1887 to 610,000,000, and in 1888 to 628,000,000 cubic metres. The figures for the last two years are approximate only. The towns lighted by gas numbered 687 in 1878, 914 in 1883, and 1,001 in 1888, and populations of 9,943,400, 11,840,000, and 12,680,000. The increase, therefore, since the last Exhibition in the number of towns lighted by gas amounts to 314, or 45 per cent.; in the number of inhabitants to 2,736,600, or 27·5 per cent.; and in the production of gas to 200,000,000 cubic metres, or 46·5 per cent.

Sponge Trade of Cuba.—Sponges are found both on the northern and the southern coast of Cuba, but the chief ports to which they are brought for sale are Batabano on the South coast, and Caibavien on the north. Consul Little, of Havana, says that the classes included are sheep wool, velvet, hard head, yellow, grass, and glova. Very little reef, if any, is found in Cuba. On the south coast sheep wool and velvet are more abundant than on the north coast. Cuban sponges find a market chiefly in England, France, and the United States. The island itself consumes about one-tenth of all the sponges brought in, and these are used especially for the damping of tobacco, and for cleaning centrifugal machines on sugar estates. The sponge fisheries employ about 1,000 hands, chosen exclusively from among the *matriculados*, or seamen who have served on Spanish men-of-war, and are still bound to serve when called upon. On the south coast are employed vessels ranging from about five to twenty tons, carrying from four to eight men, and each vessel is provided with from three to six small boats. On the north coast open boats with one or two men each are used. The annual value of the sponges brought in by these vessels is between £160,000 and £180,000.

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FRIDAY, NOVEMBER 15, 1889.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

ARRANGEMENTS FOR THE SESSION.

The First Meeting of the One Hundred and Thirty-sixth Session of the Society will be held on Wednesday, the 20th November, when the Opening Address will be delivered by the Duke of Abercorn, C.B., Chairman of the Council. Previous to Christmas there will be four Ordinary Meetings, in addition to the Opening Meeting. The following arrangements have been made :—

November 20.—Opening Address by the Duke of Abercorn, C.B., Chairman of the Council.

November 27.—J. Hall Gladstone, Ph.D., F.R.S., "Scientific and Technical Instruction in Elementary Schools." The Right Hon. A. J. Mundella, M.P., in the chair.

December 4.—Armand Ruffer, M.A., M.D., "Rabies and its Prevention."

December 11.—H. Trueman Wood, M.A., Secretary to the Society, "The Paris Exhibition." Sir Philip Cunliffe-Owen, K.C.B., K.C.M.G., C.I.E., in the chair.

December 18.— Sir Robert Rawlinson, K.C.B., "London Sewage."

Papers for which no dates have as yet been fixed :—

"The Chemin de Fer Glissant, or Sliding Railway." By Sir Douglas Galton, K.C.B., D.C.L., F.R.S.

"Modern Improvements in Facilities for Railway Travelling." By George Findlay, General Manager London and North-Western Railway.

"Commercial Geography." By J. S. Keltie.

"The Relation of the Fine Arts to the Applied Arts." By E. C. Robins.

"Ocean Penny Postage and Cheap Telegraph Communication between England and all Parts of the Empire and America." By J. Henniker Heaton, M.P.

"The Industrial Arts of Japan." By A. Lasenby Liberty.

"The Records of the India-office." By Frederick C. Danvers.

"Precious Stones at the Paris Exhibition." By H. Temple Ellicott.

"Recent Progress in British Watch and Clock Making." By J. Tripplin.

"Gold Mining in Hungary." By C. G. Warnford Lock.

Foreign and Colonial Section.

The meetings of this Section will take place on the following Tuesdays, at Five o'clock :—

January 21; February 18; March 18; April 22; May 6, 20.

Indian Section.

The meetings of this Section will take place on the following Fridays, at Five o'clock :—

January 17; February 7, 28; March 14; April 18; May 16.

Applied Art Section.

The meetings of this Section will take place on the following Tuesday evenings, at Eight o'clock :—

January 28; February 11; March 4, 25; April 15; May 13.

Cantor Lectures.

The following Courses of Cantor Lectures will be delivered on Monday evenings at Eight o'clock :—

William Jago, F.C.S., F.I.C., "Modern Developments of Bread Making." Four Lectures.
November 25; December 2, 9, 16.

Prof. Silvanus P. Thompson, "The Electromagnet." Four Lectures.
January 20, 27; February 3, 10.

Thomas Bolas, F.C.S., "Stereotyping." Three Lectures.
February 17, 24; March 3.

Prof. A. H. Church, "Some Considerations concerning Colour and Colouring." Three Lectures.
March 17, 24, 31.

Richard Bannister, "Sugar, Tea, Coffee, and Cocoa, their Origin, Preparation, and Uses." Four Lectures.
April 28; May 5, 12, 19.

Juvenile Lectures.

Two Juvenile Lectures, on "The Story of a Flame," will be given by Professor Vivian B. Lewes, on Wednesday evenings, January 1 and 8, 1890, at Seven o'clock.

UNION OF INSTITUTIONS.

The following Institution has been received into Union since the last announcement:—

York Railway Institute, York.

Miscellaneous.

THE FREE LIBRARIES OF PARIS.

In establishing popular free libraries, the Municipality of Paris endeavoured to supply a want quite different from those which were furnished by the large and rich collections of books like the National, Mazarin, Arsenal, and other libraries. The object was simply to place within the reach of all the elements of labour and study, and for their moments of leisure a salutary occupation, a means of public improvement and of popular education for those who seek instruction and intelligent distraction. To the workman it is a species of school which competes with the tavern. The object long delayed has been to provide year by year a library for each of the eighty quarters of Paris. The hours at which these are open coincides with the time of cessation from labour, when most of the shops and factories are closed, and the libraries are easy of access for the work-people. The privilege of taking home books is important, since it enables the reader to choose his most convenient hour for reading, and thus associate his family with his study or pleasure. The number of municipal free libraries—which it is hoped will ere long reach 80—is at present 57, without reckoning two specially devoted to industrial art. Each of the 20 mairies has a free library, besides 37 others installed in the public schools. Although all under the charge and care of the Prefect of the Seine, that of each arrondisement or district is under the supervision of a committee presided over by the mayor, who select the books to be purchased. The expenses are all paid by the town. The staff consists usually of a librarian, sub-librarian, and a beadle. The books are ranged on shelves without any classification according to the number they bear.

Of the 57 libraries, 34 have a reading-room, the others, from their locality, have no such advantage. In the reading-room books of a high value, which are difficult to replace in case of loss or injury, and all books of reference, and periodicals are not lent out. All books for circulation are strongly bound with the name of the library, and a certain number of the leaves and the illustrations are also stamped with the name of the library. With an annual issue of more than 1,000,000 volumes, the loss is scarcely on the average $4\frac{1}{2}$ per 1,000, and this arises more from carelessness than fraud or ill-will. These free libraries are open in the evenings from 7 to 9, or from 8 to 10 according to the localities, on Sundays from 9 to 11 in the morning, and from 10 till 12. In some districts they are open in the daytime. To borrow a book the person must be at least 16 years old and live in the locality.

The library is the common school. Rue Beranger is specially reserved for apprentices from 13 to 16 years old who live or work in the arrondisement. These youngsters, like all minors in other libraries, can only be admitted on presentation by their parents or employers, who are answerable for any damage. Each borrower receives a book gratis, in which each volume he takes out is entered, and only one volume at a time is allowed, which has to be returned in 15 days or renewed. Ten years ago, at the time of the last International Exhibition, there were only nine free libraries, and only five of these were much frequented. The whole of these in the year circulated but 29,339 volumes, or an average of 3,259 issues for each library. In 1888 the number of books borrowed or read in the 57 existing libraries (some of which were only opened in that year) were 1,277,436, or an average of 22,492. In 1877, with 54 libraries, the average was 22,100.

Allusion has already been made merely to the free libraries and reading-rooms, but there are others open to the public. Without practice books alone are not sufficient for the education of the workman or the artistic labourer, to complete his technical knowledge, to purify his taste, and devolop his imagination; the study of models and designs are indispensable. With this view municipal libraries of industrial art have been established. Of these there are eight in Paris, six of which are properly speaking recent additions to different public libraries. One of these deserves special mention having been founded with the proceeds of a legacy of £8,000 left to the City of Paris by M. Forney, and which bears his name. This professional library of art and industry is situated in the Faubourg Sainte-Antoine, that is in the chief centre of the working industry of Paris. The superintendence is confided to a special committee appointed and presided over by the Prefect of the Seine and three members of the Municipal Council, who determine what books, engravings, &c., shall be purchased. This library was opened to the public on the 1st March, 1886, and at the close of the year the total of its operations (borrowings and consultations) reached 9,413; in 1888 it had risen to 22,445. Its revenue, which is distinct from the other free libraries, consists of about £508, made up of the interest derived from the Forney legacy, and a municipal grant of £225. It possesses at present 1,854 books, and 24,522 prints, photographs, sketches, drawings, &c. There are many books

of great value which for the first time have been placed at the free disposition of workmen. This library is open daily from 1 to 3, and in the evening from 7 to 10. On Sundays from 9 to 12 and from 2 to 5. Here are to be seen all the best works, periodicals, and documents on industrial art and applied science.

Copies and chalk drawings may be made of all the designs and engravings in the library. Those borrowed are sent out in portfolios to preserve them, and are well mounted on card-board. The other industrial art libraries are founded on the same system as the Forney Library. The oldest dates from December, 1885; the most recent was opened on 25th October, 1888. In 1888 the whole of the works borrowed from these art libraries was 27,248, exclusive of the Forney Library.

CUTTLE-FISH TRADE IN CHINA.

Consul Pettus, of Ningpo, in his last report, says that one of the principal and perhaps most profitable industries of his consular district is the *ming fu* or cuttle-fish trade. For two months, from the latter part of April until the closing days of June, the number of small and somewhat barren islands of the Chusan archipelago, situated within a radius of fifty miles of Chinhae (at the mouth of the Yung river) swarm with men engaged in the occupations of cleaning and drying the fish for the Ningpo market, and the adjacent waters are covered with boats engaged in fishing. The cuttle-fish boats are from 25 feet to 30 feet in length, with a beam of 7 feet. They are furnished with a single lug-sail, usually made of foreign cloths tanned with mangrove bark. They are worked with two, sometimes three, oars, with which the boats are propelled with immense speed. The boats, as a rule, work in pairs, a bamboo fastened at the bows of each to keep them separated, with a space of about 20 feet between. To the bamboo is attached the large net. Others, again catch the fish by means of a square net, fastened at the corners to the ends of two slender bamboos, which cross at right angles, and sewn together in the middle. These bamboos, with the attached net, are suspended from a stout beam which projects some distance over the bow, and has fastened to the inboard end a heavy weight for facilitating the raising of the net. This is used in shallow water, and principally at night, when a fire is kept burning in a pan in the bow of the boat to attract the fish. One or two men attend to the working of this net while the rest of the crew are employed in scooping in the fish with hand-nets. The fish are then landed, cleaned, and sun-dried, the latter operation taking about three days. The cuttle fish is called by the Chinese, *uri tsê* (black thief); *ming fu* is the commercial name of the fish when dried. The black liquid secreted by the fish was used as a substitute for ink, but was abandoned, as it faded after a lapse of a few years.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, Nov. 18...British Architects, 9, Conduit-street, W., 8 p.m.
Medical, 11, Chandos-street, W., 8½ p.m.
Asiatic, 22, Albemarle-street, W., 4 p.m.

TUESDAY, Nov. 19...Civil Engineers, 25, Great George-street, S.W., 8 p.m. Mr. John I. Thornycroft, "Water-Tube Steam-Boilers for Marine Engines."
Statistical, School of Mines, Jermyn-street, S.W., 7¾ p.m.
Pathological, 20, Hanover-square, W., 8½ p.m.
Zoological, 11, Hanover-square, W., 8½ p.m. 1. Mr. O. W. Butler, "The Subdivision of the Body-cavity in Lizards, Crocodiles, and Birds." 2. Mr. J. H. Leech, "The Lepidoptera of Japan and Corea. Part III. Heterocera. Section II. *Noctuæ* and *Deltoidæ*." 3. Mr. R. Lydekker, "Associated Remains of a Theriodont Reptile from the Karoo System of the Cape."

WEDNESDAY, Nov. 20...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Opening Address of the 136th Session by the Duke of Abercorn, Chairman of Council.
Meteorological, 25, Great George-street, S.W., 7 p.m. 1. Mr. William Marriott, "Second Repotr of the Thunderstorm Committee.—Distribution of Thunderstorms over England and Wales, 1871-1877." 2. Mr. G. M. Whipple, "The Change of Temperature which accompanies Thunderstorms in Southern England." 3. Mr. W. H. Dines, "Note on the Appearance of St. Elmo's Fire at Walton-on-the-Naze, September 3rd, 1889." 4. Mr. H. Helm Clayton, "Notes on Cirrus Formation." 5. Mr. F. C. Bayard, "A Comparison between the Jordan and the Campbell-Stokes Sunshine Recorders." 6. Mr. A. B. MacDowall, "Sunshine." 7. Prof. S. A. Hill, "Climatological Observations at Ballyboley, Co. Antrim."
Geological, Burlington-house, W., 8 p.m. 1. Mr. R. Lydekker, "The Occurrence of the Striped Hyæna in the Tertiary of the Val d'Arno." 2. Mons. F. M. Corpi, "The Catastrophe of Kantzorik, Armenia." 3. Dr. G. J. Hinde, "A new Genus of Siliceous Sponges from the Lower Calcareous Grit of Yorkshire."
Archæological Association, 32, Sackville-street, W., 8 p.m.

THURSDAY, Nov. 21...Royal Burlington-house, W., 4½ p.m. 1. Prof. W. Hatchett Jackson, "External Anatomical Characters indicating sex in Chrysalids, and development of the Azygos oviduct and its accessory organs in *Vanessa*." 2. Mr. E. B. Poulton, "Anatomy of Lepidoptera." 3. Mr. John H. Leech, "Lepidoptera of Tchang, North China."
Chemical, Burlington-house, W., 8 p.m.
Camera Club, Bedford-street, Strand, W.C., 8 p.m. Mr. Alfred Maskell, "The Progress of Hydroquinone."
Historical, 11, Chandos-street, W., 8½ p.m.
Numismatic, 4, St. Martin's-place, W.C., 7 p.m.

FRIDAY, Nov. 22...Quekett Microscopical Club, University College, W.C., 8 p.m.
Clinical, 20, Hanover-square, W., 8½ p.m.

SATURDAY, Nov. 23...Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m.

ERRATUM.—The date of the Newcastle Exhibition was erroneously given in last week's *Journal* as 1886 instead of 1887.

CONTRIBUTIONS TO THE READING-ROOM.

The Council beg leave to acknowledge, with thanks to the Proprietors, the regular receipt of the following Transactions of Societies and Periodicals.

TRANSACTIONS, &c.

American Academy of Arts and Sciences, Proceedings and Memoirs.
American Chemical Society, Journal.
American Institute of Electrical Engineers, Transactions.
American Philosophical Society, Proceedings.
American Society of Civil Engineers, Transactions.
Association of Engineering Societies, Journal.
Bath and West of England Society, Journal.
Berlin, Polytechnische Gesellschaft, Verhandlungen
Birmingham Philosophical Society, Proceedings.
British Association for the Advancement of Science, Report.
British Guiana, Royal Agricultural and Commercial Society of, Journal.
British Horological Institute, Horological Journal.
Camera Club, Journal.
Canada, Royal Society of, Proceedings and Transactions.
Canadian Institute, Proceedings.
Central Chamber of Agriculture, Proceedings.
Chemical Society, Journal.
Cleveland Institution of Engineers, Proceedings.
County of Middlesex Natural History and Science Society, Transactions.
Doubs, Société d'Emulation du, Mémoires.
East India Association, Journal.
Farmers' Club, Journal.
Franklin Institute, Journal.
Gas Institute, Transactions.
Geological Society, Quarterly Journal.
Geologists' Association, Proceedings.
Glasgow Philosophical Society, Proceedings.
India, Geological Survey of, Memoirs, Records and Palæontologia Indica.
Indian Meteorological Memoirs.
Institute of Bankers, Journal.
Institute of Patent Agents, Transactions.
Institution of Civil Engineers, Minutes of Proceedings.
Institution of Civil Engineers of Ireland, Transactions.
Institution of Electrical Engineers, Journal.
Institution of Engineers and Shipbuilders in Scotland, Transactions.
Institution of Mechanical Engineers, Proceedings.
Institution of Naval Architects, Transactions.
Iron and Steel Institute, Journal.
Junior Engineering Society, Publications.
Kew Gardens Bulletin.
Linnæan Society, Journal.
Liverpool Literary and Philosophical Society, Proceedings.
Liverpool Polytechnic Society, Journal.
London Association of Foremen Engineers and Draughtsmen, Publications.
Lyons, Société des Sciences Industrielles, Annales.
Manchester Literary and Philosophical Society, Memoirs and Proceedings.
Manitoba Historical and Scientific Society, Transactions.
Mauritius, Société Royale des Arts et des Sciences, Transactions.
Munich, Polytechnischer-Verein, Bayerisches Industrie-und-Gewerbeblatt.
National Indian Association, "The Indian Magazine."
Nederlandsche Maatschappij ter Bevordering van Nijverheid, Tidjschrift.
North-East Coast Institution of Engineers and Shipbuilders, Transactions.
Nova Scotian Institute of Natural Science, Proceedings and Transactions.
Pharmaceutical Society, Journal and Transactions.
Philadelphia, Academy of Natural Sciences, Proceedings.
Philadelphia, Engineers Club of, Proceedings.
Photographic Society of Great Britain, Journal.
Physical Society of London, Proceedings.
Quekett Microscopical Club, Journal.
Royal Agricultural Society, Journal.
Royal Astronomical Society, Memoirs.
Royal Colonial Institute, Proceedings.
Royal Cornwall Polytechnic Society, Annual Report.
Royal Geographical Society, Proceedings and Journal.
Royal Geological Society of Ireland, Journal.
Royal Historical and Archœological Association of Ireland, Journal.
Royal Institute of British Architects, Journal of Proceedings and Transactions.
Royal Institution of Great Britain, Proceedings.
Royal Irish Academy, Transactions and Proceedings.
Royal Meteorological Society, Quarterly Journal.
Royal National Life Boat Institution, "The Life Boat."
Royal Scottish Society of Arts, Transactions.
Royal Society, Philosophical Transactions and Proceedings.

Royal Society of Edinburgh, Transactions and Proceedings.
Royal Statistical Society, Journal.
Royal United Service Institution, Journal.
Schlesische Gesellschaft für vaterländische Cultur, Jahres Bericht.
Société d'Encouragement pour l'Industrie Nationale, Bulletin.
Société Internationale des Electriciens, Bulletin.
Société Nationale d'Acclimatation de France, Bulletin Bimensuel.
Society of Antiquaries, Archæologia and Proceedings.
Society of Biblical Archæology, Transactions and Proceedings.
Society of Chemical Industry, Journal.
Society of Cymmrodorion, Magazine.
Society of Dyers and Colourists, Journal.
Society of Engineers, Transactions.
South Wales Institute of Engineers, Proceedings.
Victoria Institute, Journal of the Transactions.
Vienna, Das Handels-Museum.
Württemburg, Königliche Centralstelle für Gewerbe und Handel, Jahresberichte.
Zoological Society, Proceedings and Transactions.

PERIODICALS.

Twice a Week.

Chemiker-Zeitung.
Commissioners' of Patents Journal.

Weekly.

Accountant.
Amateur Photographer.
American Gas Light Journal.
American Architect and Building News.
American Manufacturer and Iron World.
Architect.
Athenæum.
Bradstreet's.
British Architect.
British Journal of Photography.
British and Colonial Druggist.
Builder.
Builders' Weekly Reporter.
Building (New York).
Building News.
Chemical News.
Chemist and Druggist.
Civil Service Competitor.
Colliery Guardian.
Colonies and India.
Cosmos ; Revue des Sciences.
Electrical Engineer.
Electrician.
Electricité.
Engineer.
Engineerng.
Engineering and Building Record (New York).
English Mechanic.
European Mail.
Farmer and Stock Breeder.
Gardeners' Chronicle.
Gardening World.
Gas and Water Review.
Gas World.
Herapath's Railway Journal.
Industries.
Invention.
Iron.
Ironmongery.
Iron and Coal Trades Review.
Iron and Steel Trades Journal.
Ironmonger.
Jewelers' Weekly (New York).
Journal of Gas Lighting.
Journal d'Hygiène.
Journal des Mines.
Land and Water.
London Iron Trade Exchange.
Medical Press and Circular.
Metropolitan.
Miller.
Millers' Gazette.
Mining Journal.
Moniteur Industriel.
Musical Standard.
Musical World.
Nature.
Photographic News.
Photographic Review.
Photographic Times and American Photographer.
Pottery and Glassware Reporter (Pittsburgh).
Practical Engineer.
Produce Markets' Review.
Queen.
Railway Press.
Revue Industrielle.
School Board Chronicle.
Schoolmaster.
Science (New York).
Scientific American.
Statist.
Telegraphic Journal and Electrical Review.
Textile Mercury.
United States Patent Office, Official Gazette.
Warehousemen and Drapers' Trade Journal.

Fortnightly.

Anthony's Photographic Bulletin.
Brewers' Guardian.
Corps Gras Industriels.
Country Brewers' Gazette.
Finance Chronicle.
Gaceta Industrial.
Ingeniero y Ferretero Espanol y Sud-Americano.
Irish Builder.
Jeweller and Metalworker.
Moniteur des Produits Chimiques.
Planters' Gazette.

Publishers' Circular.
Revue Internationale de l'Electricité.

Monthly.

Analyst.
Antiquary.
Art Journal.
Bookbinder.
Bookseller.
Brewers' Journal.
British Mail.
British Mercantile Gazette.
British Trade Journal.
Building Societies' Gazette.
Cabinet Maker and Art Furnisher.
Canadian Patent Office Record.
Caterer and Refreshment Contractors' Gazette.
Cigar and Tobacco World.
Confectioners' Union.
County Council Magazine.
Dental Record.
Drinks.
Dyer and Calico Printer.
Educational Times.
Electrical Plant.
Furniture Gazette.
Giornale del Genio Civile.
Inland Architect (Chicago).
Irish Textile Journal.
Journal of Decorative Art.
Leather Trades' Circular.
Machinery Market.
Manufacturer and Inventor.
Manufacturers' Chronicle.
Manufacturers' Review and Industrial Record.
Marine Engineer.
Martineau & Smith's Hardware Trade Journal.
Midland Naturalist.
Mineral Water Trade Review and Guardian.
Monde de la Science et de l'Industrie.
Moniteur Scientifique.
Musical Times.
Newsagent.
Oestereichische Monatsschrift für den Orient.
Paper Makers' Monthly Journal.
Photographer's World.
Plumber and Decorator.
Pottery Gazette.
Private Schoolmaster.
Propriété Iudustrielle.
Publication Industrielle d'Armengand Ainé Revue illustrée, des Machines, Appareits et Procédés.
Saddlers, Harness Makers, and Carriage Builders' Gazette.
Sanitary Record.
Science and Art.
Sugar Cane.
Symons's Monthly Meteorological Magazine.
Textile Recorder.
Textile World.
Ulster Agriculturist.
Union Horlogère.
Watchmaker, Jeweller, and Silversmith.
Wine, Spirit, and Beer.
Wine Trade Review.

Two-Monthly.

Coach Builders', Harness Makers', and Saddlers' Art Journal.

Quarterly.

Asclepiad, by Dr. B. W. Richardson, F.R.S.
Technology Quarterly (Boston, Mass.).

NEWSPAPERS.

Belgian News.
Bombay Gazette (Overland Summary).
Ceylon Observer (Overland Edition).
Ceylon Times (Weekly Summary).
Eastern Post.
Empire.
Home and Colonial Mail.
London Commercial Record.
London and China Telegraph.
Newcastle Weekly Chronicle.
Nottinghamshire Guardian.
Sheffield and Rotherham Independent.
Times of India (Overland Weekly Edition).
West London Observer.

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